HIGH-END COMPUTING CAPABILITY PORTFOLIO

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NASA Advanced Supercomputing Division

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National Aeronautics and Space Administration

Aitken AMD Apollo 9000 Badger Expansion in Production

- HECC's Supercomputing System Group completed the Aitken expansion and placed the system into production—dramatically increasing HECC's compute capability.
- The expansion increases Aitken's performance by 168.5%, to a total of 6.39 petaflops (PF) on the LINPACK benchmark.
- The expansion comprises eight Apollo 9000 "Badger" racks containing 1,024 AMD "Rome" compute nodes. The HPE Performance Cluster Manager (HPCM) is used for managing the cluster configuration.
  - Each node has two 64-core AMD second-generation System-on-Chip (SoC) EPYC (pronounced "epic") 7742 Rome processors.
  - Provides 131,072 additional cores and adds 524 terabytes memory.
  - The expansion alone measures 4.01 PF on the LINPACK benchmark.
  - The SBU* rate for an AMD Rome node is 4.06. The Aitken Rome nodes provide a total of 36.4 million annual SBUs in the HECC compute capacity, which is a 2.2X increase over the Aitken Cascade Lake nodes.
- The combined Aitken system would rank at 43 if ranked today on the November 2020 TOP500 list.

** 1 SBU equals 1 hour of a Pleiades Broadwell 28-core node.*

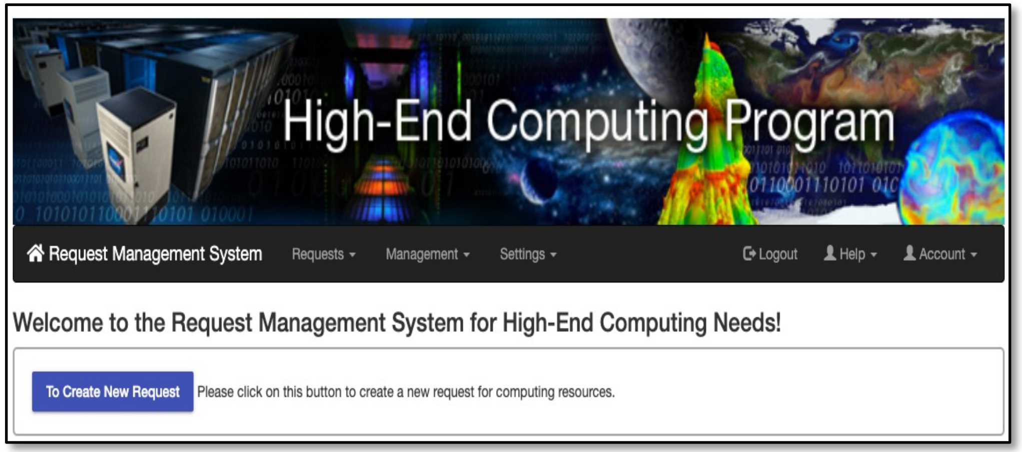
IMPACT: The Aitken expansion provides more computing capacity and resources to support research engineers and scientists for NASA mission projects.

The eight racks of the Aitken expansion provide 1,024 AMD EPYC 7742 Rome nodes with 128 cores per node. With 131,072 cores, the expansion has more total cores than the entire Electra system.
Matt Lepp, Unisys

Resource Management System Version 1.4 Released

- HECC, in collaboration with NCCS, released version 1.4 of the Request Management System (RMS) on February 23, 2021. This tool is being developed in phases to replace REI eBooks. The eBooks contract ends on March 31, 2021.
- Version 1.4 concentrated on migrating user data from eBooks to RMS; allocation, request, and user data were all successfully migrated to the new RMS system.
- The RMS tool enables new features such as:
  - Generating exportable reports by fiscal year.
  - Generating exportable reports for funding confirmation, allocation, and modification.
  - Enabling bulk allocation through Excel, rather than doing each allocation by hand.
  - Greater flexibility in customization and significant cost savings.
- RMS opened to all mission directorates on February 26.
- Completion of this milestone concluded the fourth phase of a multi-phase collaboration.

IMPACT: Creating in-house-developed software to manage supercomputer resource allocation requests allows NASA's High End Computing Program more ownership of the data and simplifies the process for reviewing allocations and targets.



Snapshot of the welcome page for the Request Management System.

New Storage Systems Procured to Meet User Needs

- HECC procured two storage systems to expand its storage capacity, increase reliability, and improve filesystem performance in order to meet the growing requirements of users in the areas of science, simulation, artificial intelligence, and machine learning.
- DataDirect Networks (DDN): 3,600 18-terabyte (TB), 7.2K-RPM drives, 12-gigabytes/second Serial Attached SCSI (SAS), 4K-hard disk drive (HDD) module, 240 15.36 TB-1 Drive Writes Per Day (DWPD) dual-port NVMe self-encrypting drive (SED)-capable, 4K-solid-state drive (SSD) module.
  - Two large filesystems, each with: Total usable HDD of 18 petabytes (PB); total usable Non-Volatile Memory Express (NVMe) of 1 PB.
  - One smaller filesystem: Total usable HDD of 9 PB; total usable NVMe of 500 TB.
- VAST: Four 2U HA VAST Enclosure systems:
  - Raw Capacity: 2,704 TB.
  - Capacity (Initial Use): 2,385 TB.
  - Estimated Cluster Read/Write Random Bandwidth: 112 GB/s and 25 GB/s, respectively.

IMPACT: This procurement allows HECC to provide users with more storage capacity and resources to support NASA's rapidly accelerating growth in scientific and engineering data.

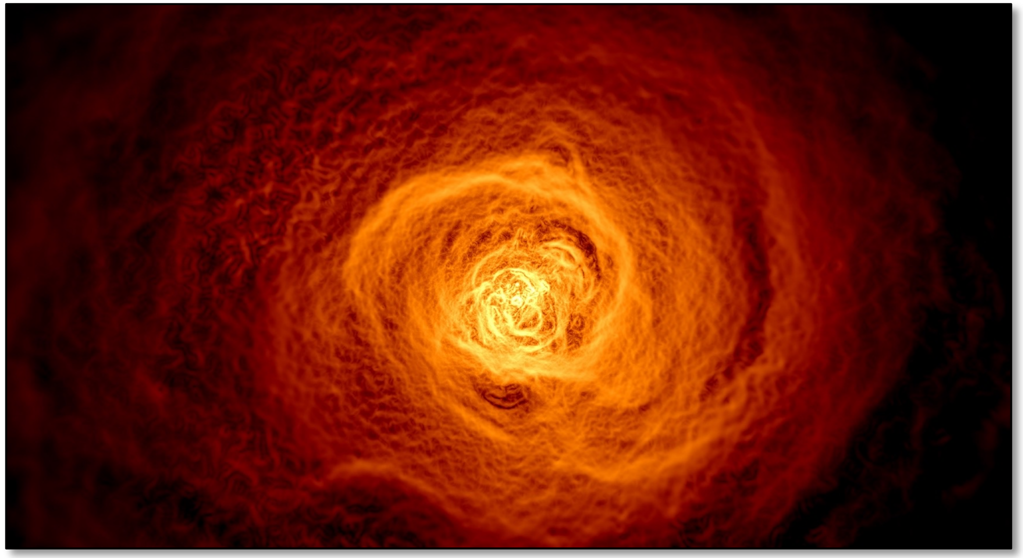
Photograph of the installed DDN hardware at the NAS facility.
Jonathan LaBounty, Inuteq

Simulations of Giant Cold Fronts in Clusters of Galaxies *

- Astrophysicists used numerical simulations on the Pleiades supercomputer to model collisions between clusters of galaxies that produce features known as “cold fronts”—jumps in gas density and temperature that are visible as edges in X-ray observations. These simulations were then compared to observational data from missions such as the Chandra X-ray Observatory in order to better understand the complex physics of hot gas at work.
- Merging galaxy clusters produce cold fronts by bringing together gases of different temperatures and densities. These cold fronts manifest as wave-like features that expand outward from the cluster center. Along the front boundary, a shear flow—which can excite fluid fluctuations such as Kelvin-Helmholtz instabilities—produce these wave-like features along the surface.
- The simulations also included the effects of dark matter, gravity, and magnetohydrodynamics. In the different simulations, researchers were able to vary the magnetic field strength or viscosity in order to predict what might be seen in observational data in these cases.
- In order to conduct these physics simulations, which needed to include the full dynamics of two merging clusters on the scale of thousands to millions of light-years, the team used millions of core-hours on the Pleiades supercomputer over the past several years and generated tens of terabytes of 3D simulation data, with each simulation requiring 1,000 cores each.

** HECC provided supercomputing resources and services in support of this work*

IMPACT: This work showed that numerical simulations of galaxy cluster mergers on HECC supercomputers were able to reproduce features from observations, and also revealed new details about the complex physics at work within these mergers.



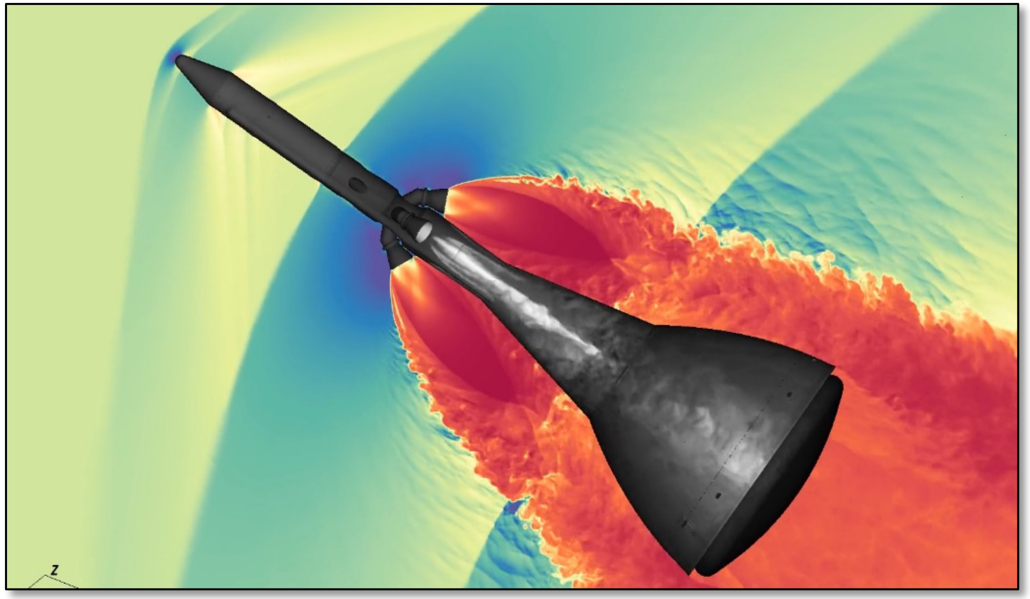
Chandra images and a computer simulation show a wave spanning 200,000 light-years rolling through the Perseus galaxy cluster. When a small galaxy cluster disturbs a larger one, such giant waves can emanate for millions of years. *John ZuHone, Center for Astrophysics |Harvard & Smithsonian; Stephen Walker, University of Alabama in Huntsville*

Predicting Orion LAS Vibrations to Keep Astronauts Safe *

- The Launch, Ascent, and Vehicle Aerodynamics (LAVA) team at the NASA Advanced Supercomputing Division produced a detailed, turbulence-resolving simulation of the Orion Launch Abort System (LAS) Ascent Abort Test 2 (AA-2), conducted in July 2019, to investigate the effect of altitude and velocity on the unsteady loads measured on the LAS surface when abort is triggered.
  - Demonstrating a growing new capability for NASA, this was the first turbulence-resolving simulation of an ascent abort scenario with enough fidelity and time integration to accurately predict the acoustic vibrations and their spatial correlation on the surface of the LAS across a wide range of frequencies, when compared to the flight test data.
  - The simulation was completed with modest resources in a short-enough turnaround time to affect engineering decisions.
- Results significantly contributed to a better understanding of the effects of altitude and velocity on the acoustic environment.
- The simulation was the latest in the LAVA team's close collaboration with the Orion Loads and Dynamics team at Johnson Space Center to help characterize the vibrations imparted by the abort motor plumes onto the LAS structure.

** HECC provided supercomputing resources and services in support of this work*

IMPACT: The simulations will help reduce uncertainty for launch abort scenarios that are difficult or too expensive to test, helping to reduce risk and ensure the safety of astronauts.



Scale-resolving simulation of supersonic AA-2 flight test during its initial firing sequence when the vehicle is moving at nearly 1.2 times the speed of sound. The video shows a slice through the density field where high density is blue (air), and low density is red (hot exhaust gas). *Francois Cadieux, Cetin Kiris, NASA/Ames*

Papers

- “**A Modelling Framework for a Better Understanding of the Tropically-Forced Component of the Indian Monsoon Variability**,” E. Swenson, D. Straus, Journal of Earth System Science, vol. 130, February 2, 2021. *
https://link.springer.com/article/10.1007/s12040-020-01503-z
- “**Long-Range Transport of Siberian Biomass Burning Emissions to North America During FIREX-AQ**,” M. Johnson, K. Strawbridge, K. E. Knowland, C. Keller, M. Travis, Atmospheric Environment, published online February 2, 2021. *
https://www.sciencedirect.com/science/article/pii/S1352231021000595
- “**Two Massive Jupiters in Eccentric Orbits from the TESS Full Frame Images**,” M. Ikwut-Ukwa, et al., arXiv:2101.02222 [astro-ph.EP], February 3, 2021. *
https://arxiv.org/abs/2102.02222
- “**Dispersion Measure Distributions of Fast Radio Bursts Due to the Intergalactic Medium**,” I. Medlock, R. Cen, Monthly Notices of the Royal Astronomical Society, vol. 502, issue 3, published online February 4, 2021. *
https://academic.oup.com/mnras/article-abstract/502/3/3664/6128658
- “**Multimessenger Binary Mergers Containing Neutron Stars: Gravitational Waves, Jets, and γ-Ray Bursts**,” M. Ruiz, S. Shapiro, A. Tsokaros, arXiv:2102.03366 [astro-ph.HE], February 5, 2021. *
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- “**Binary Planetesimal Formation from Gravitationally Collapsing Pebble Clouds**,” D. Nesvorny, et al., The Planetary Science Journal, vol. 2, no. 1, February 10, 2021. *
https://iopscience.iop.org/article/10.3847/PSJ/abd858/meta

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Papers (cont.)

- “**Improving Estimates of $PM_{2.5}$ Concentration and Chemical Composition by Application of High Spectral Resolution Lidar (HSRL) and Creating Aerosol Types from Chemistry (CATCH) Algorithm**,” N. Meskhidze, et al., Atmospheric Environment, vol. 250, published online February 11, 2021. *
https://www.sciencedirect.com/science/article/pii/S1352231021000686
- “**TESS Hunt for Young and Maturing Exoplanets (THYME) V: A Sub-Neptune Transiting a Young Star in a Newly Discovered 250 Myr Association**,” B. Tofflemire, et al., arXiv:2102.06066 [astro-ph.SR], February 11, 2021. *
https://arxiv.org/abs/2102.06066
- “**Heat Transfer Augmentation by Recombination Reactions in Turbulent Reacting Boundary Layers at Elevated Pressures**,” N. Perakis, O. Haidn, M. Ihme, arXiv:2102.06821 [physics.flu-dyn], February 12, 2021. *
https://arxiv.org/abs/2102.06821
- “**Precise Transit and Radial-Velocity Characterization of a Resonant Pair: A Warm Jupiter TOI-216c and Eccentric Warm Neptune TOI-216b**,” R. Dawson, et al., arXiv:2102.06754 [astro-ph.EP], Feburary 12, 2021. *
https://arxiv.org/abs/2102.06754
- “**Formation of a Low-Level Barrier Jet and Its Modulation by Dust Radiative Forcing Over the Hexi Corridor in Central China on March 17, 2010**,” S.-H. Chen, B. McDowell, C.-C. Huang, T. Nathan, Quarterly Journal of the Royal Meteorological Society, February 12, 2021. *
https://rmets.onlinelibrary.wiley.com/doi/abs/10.1002/qj.4000
- “**HD 219134 Revisited: Planet d Transit Upper Limit and Planet f Transit Nondetection with ASTERIA and TESS**,” S. Seager, et al., The Astronomical Journal, vol. 161, no. 3, February 12, 2021. *
https://iopscience.iop.org/article/10.3847/1538-3881/abcd3d/meta

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Papers (cont.)

- "**The Formation of Electron Outflow Jets with Power-Law Energy Distribution in Guide-Field Magnetic Reconnection**," H Che, G. Zank, A. Benz, B. Tang, C. Crawford, The Astrophysical Journal, vol. 908, no. 1, Feburary 15, 2021. *
  https://iopscience.iop.org/article/10.3847/1538-4357/abcf29/meta
- "**Spectral Signatures of Population III and Envelope-Stripped Stars in Galaxies at the Epoch of Reionization**," E. Berzin, A. Secunda, R. Cen, A. Menegas, Y. Götberg, arXiv:2101.08408 [astro-ph.GA], February 16, 2021. *
  https://arxiv.org/abs/2102.08408
- "**Figuring Out Gas & Galaxies in ENZO (FOGGIE) V: The Virial Temperature Does Not Describe Gas in a Virialized Galaxy Halo**," C. Lochhaas, et al., arXiv:2102.08393 [astro-ph.GA], February 16, 2021. *
  https://arxiv.org/abs/2102.08393
- "**The Origins of Off-Center Massive Black Holes in Dwarf Galaxies**," J. Bellovary, et al., arXiv:2102.09566 [astro-ph.GA], February 18, 2021. *
  https://arxiv.org/abs/2102.09566
- "**HYPERS Simulations of Solar Wind Interactions with the Earth's Magnetosphere and the Moon**," Y. Omelchenko, V. Roytershteyn, L.-J. Chen, J. Ng, H. Hietala, Journal of Atmospheric and Solar-Terrestrial Physics, published online February 22, 2021. *
  https://www.sciencedirect.com/science/article/abs/pii/S1364682621000456
- "**Threaded-Field-Line Model for the Low Solar Corona Powered by the Alfvén Wave Turbulence**," I. Sokolov, et al., The Astrophysical Journal, vol. 908, no. 2, February 22, 2021. *
  https://iopscience.iop.org/article/10.3847/1538-4357/abc000

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Papers (cont.)

- “**Carbon Monitoring System Flux Net Biosphere Exchange 2020 (CMS-Flux NBE 2020)**,” J. Liu, et al., Earth System Science Data, vol. 13, issue 2, February 22, 2021. *
https://essd.copernicus.org/articles/13/299/2021/
- “**Mass and Density of the Transiting Hot and Rocky Super-Earth LHS 1478 b [TOI-1640 b)**,” M. Soto, et al., arXiv:2102.11640 [astro-ph.EP], February 23, 2021. *
https://arxiv.org/abs/2102.11640
- “**Stabilization of the Adjoint for Turbulent Flows**,” A. Garai, S. Murman, AIAA Journal, published online February 24, 2021. *
https://doi.org/10.2514/1.J059998

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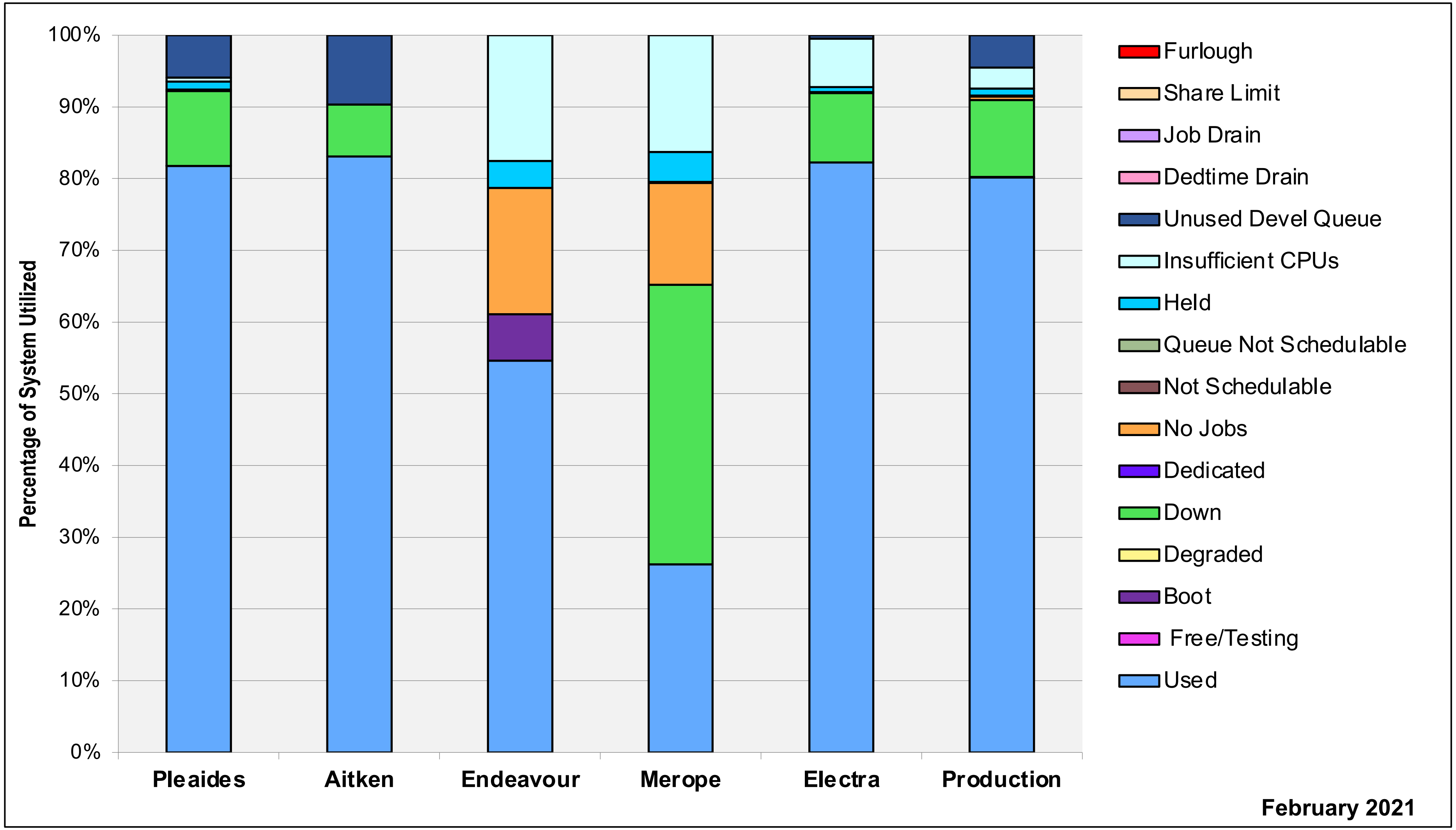
News and Events

- **LAVA: NASA's Hottest Flow Solver Contributes to Astronaut Safety**, *Image Feature–NASA Advanced Supercomputing Division*, February 4, 2021–The NAS Division's Launch Ascent and Vehicle Aerodynamics (LAVA) software is helping to reduce risk and ensure the safety of astronauts on the launch pad and during the moments after takeoff. *https://www.nas.nasa.gov/publications/articles/feature_LAVA_contributes_to_astronaut_safety.html*
- **Solar Physicist Proposes New Mechanism for How Electrons Work in Solar Flares**, *The University of Alabama in Huntsville*, February 8, 2021–A new mechanism to explain how electrons work in solar flares has been proposed by a University of Alabama in Huntsville solar physicist using a theoretical model of particle acceleration. Modeling work utilizes the supercomputers at the NASA Advanced Supercomputing facility, which will soon be compared to direct solar observations from two spacecraft. *https://www.uah.edu/news/items/solar-physicist-proposes-new-mechanism-for-how-electrons-work-in-solar-flares*

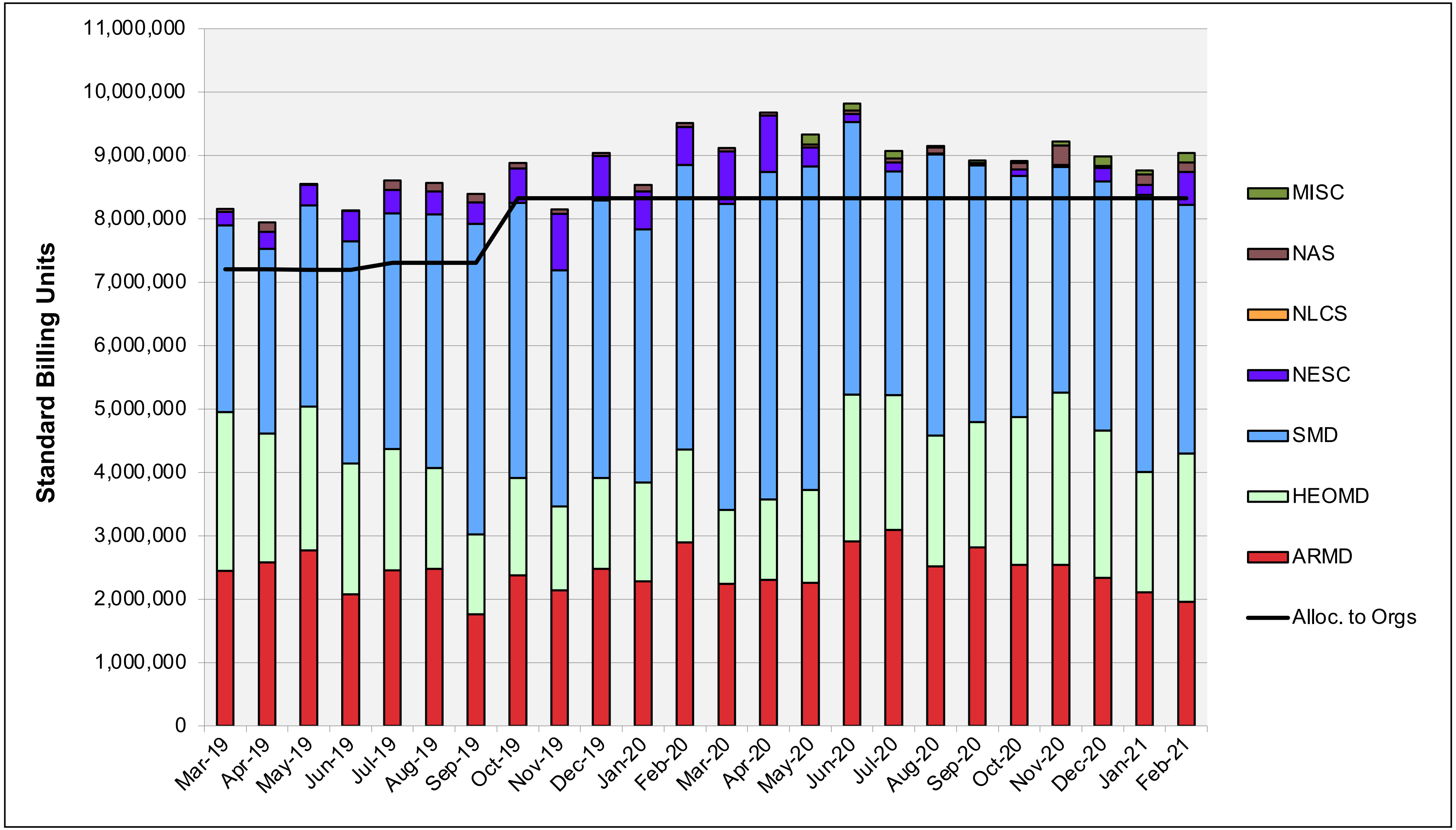
News and Events: Social Media

- **Coverage of NAS Stories**
  - Achievements of LAVA framework (feature story):
    - NASA Supercomputing: Twitter 1 retweet, 5 favorites; Facebook 542 users reached, 49 engagements, 10 likes, 7 shares.
    - NAS: Twitter 1 retweet, 8 favorites.
  - NASA Supercomputing, as part NASA's #CountdownToMars campaign:
    - NASA Supercomputing: Facebook 372 users reached, 26 engagements, 14 likes, 5 shares.
    - EDL Modeling by Langley Researchers
      - NASA Supercomputing: Twitter 3 retweets, 8 favorites
    - Heatshield Modeling Done on HECC Resources
      - NAS: Twitter 3 retweets, 15 likes; Twitter 1 retweet, 4 favorites
      - NASA Supercomputing: 360 users reached, 23 engagements, 14 likes, 3 shares.
    - Mars Cloud and Water Cycle Modeling Done on HECC Resources
      - NAS: Twitter 4 retweets, 4 favorites
      - NASA Supercomputing: Facebook 779 users reached, 59 engagements, 20 likes, 5 shares.

HECC Utilization



HECC Utilization Normalized to 30-Day Month



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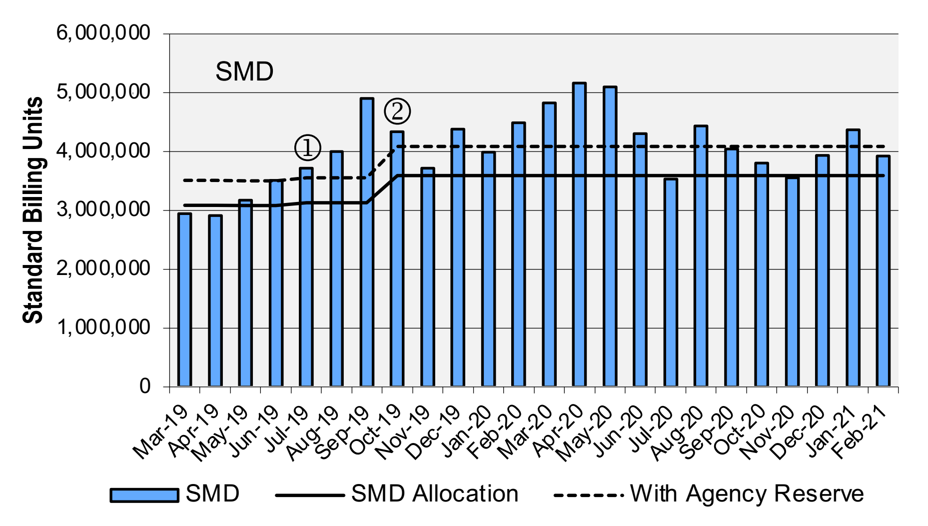
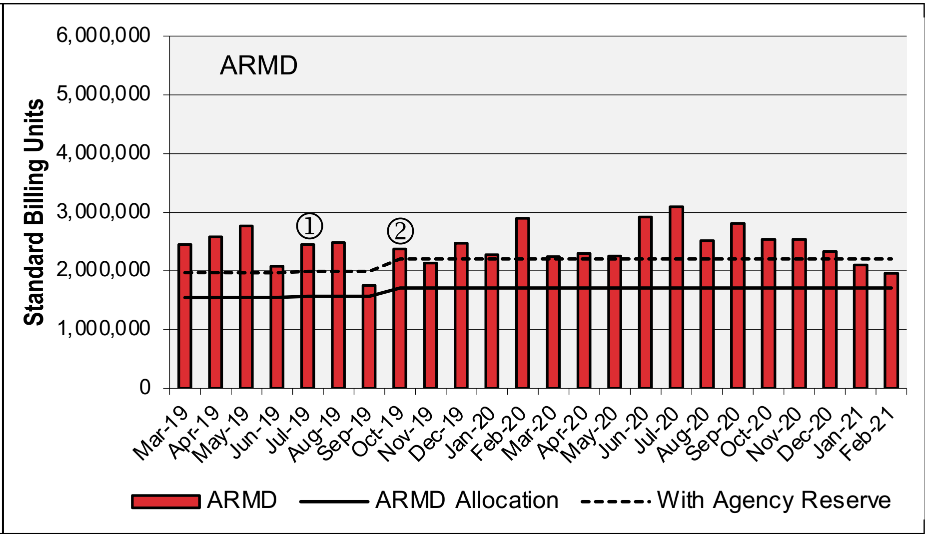
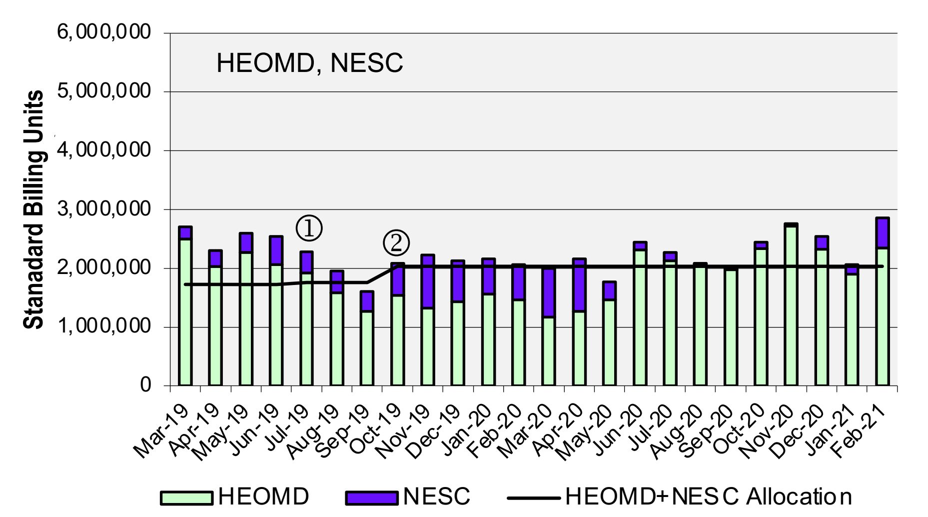


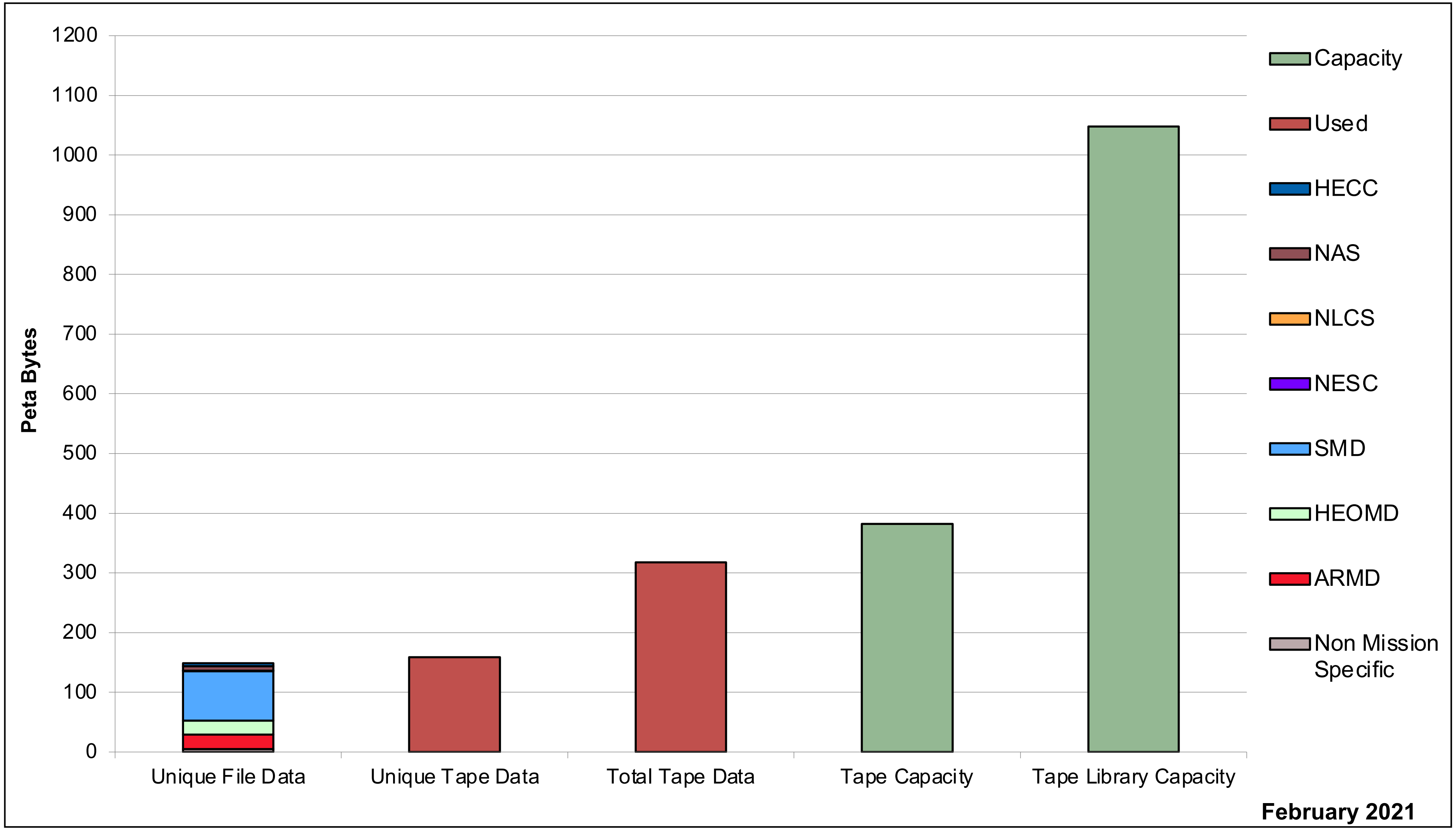




① Skylake Tesla GPU V100 Nodes installed

② 4 Cascade Lake E cells introduced into Aitken

Tape Archive Status



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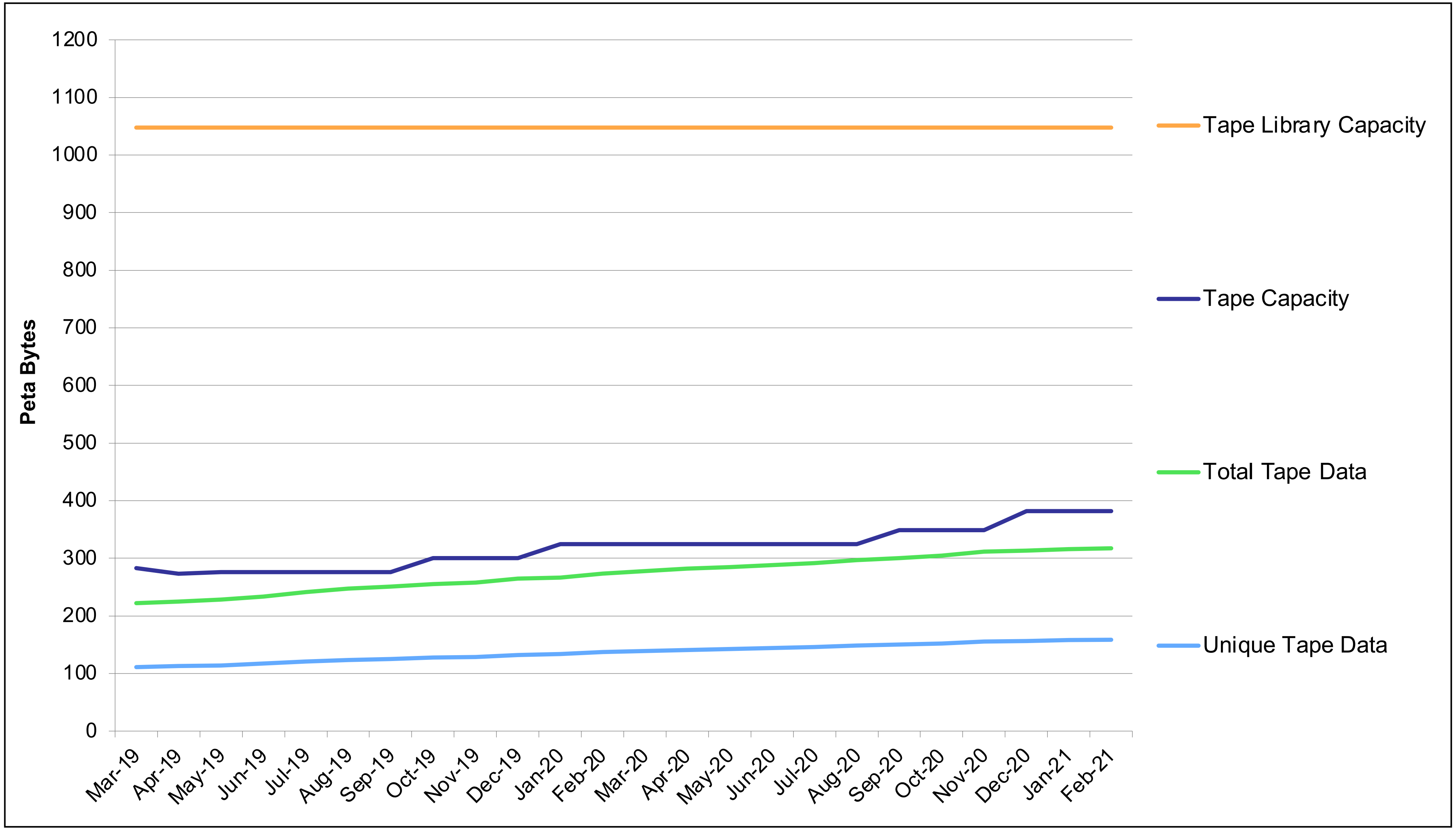
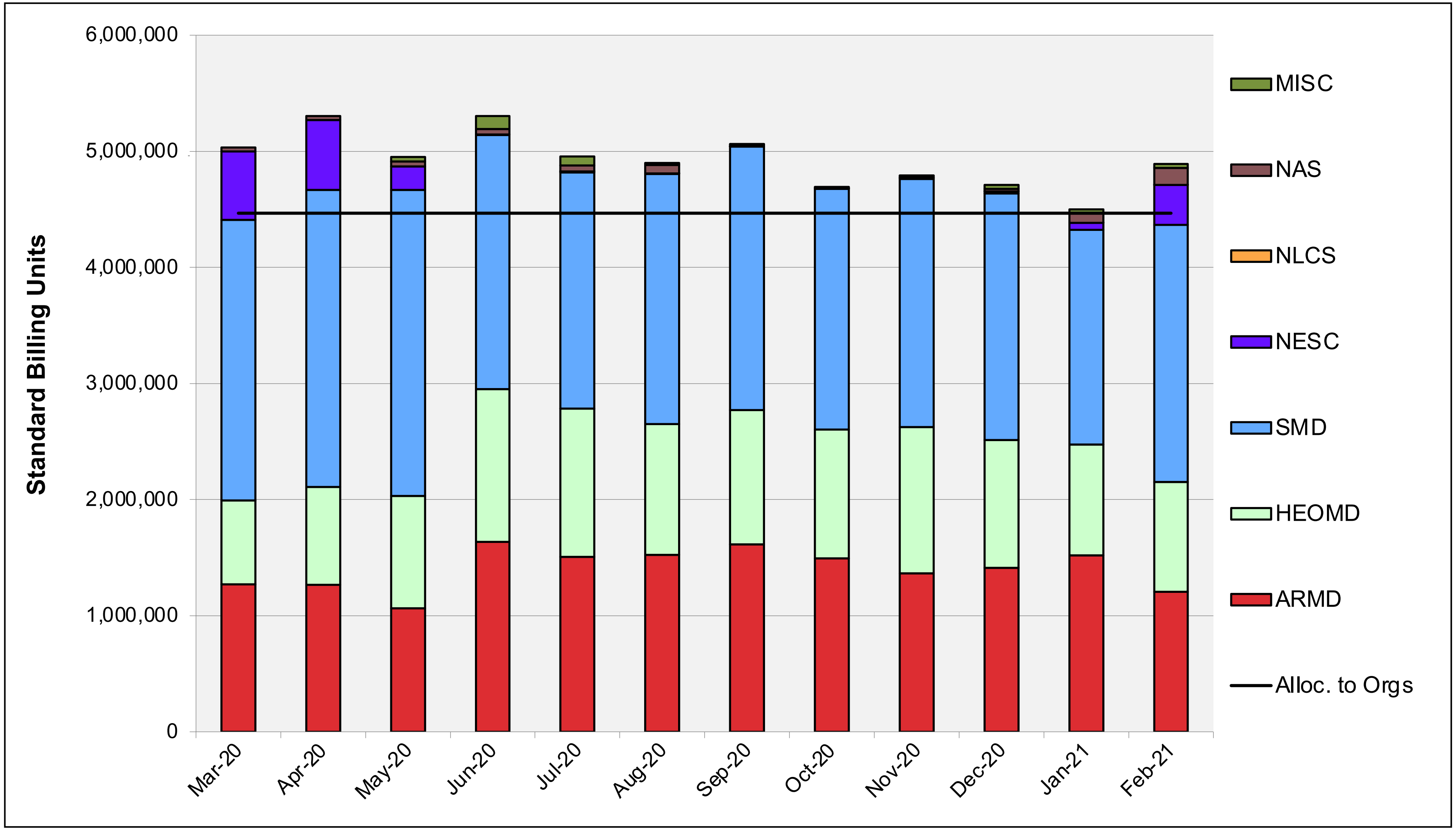
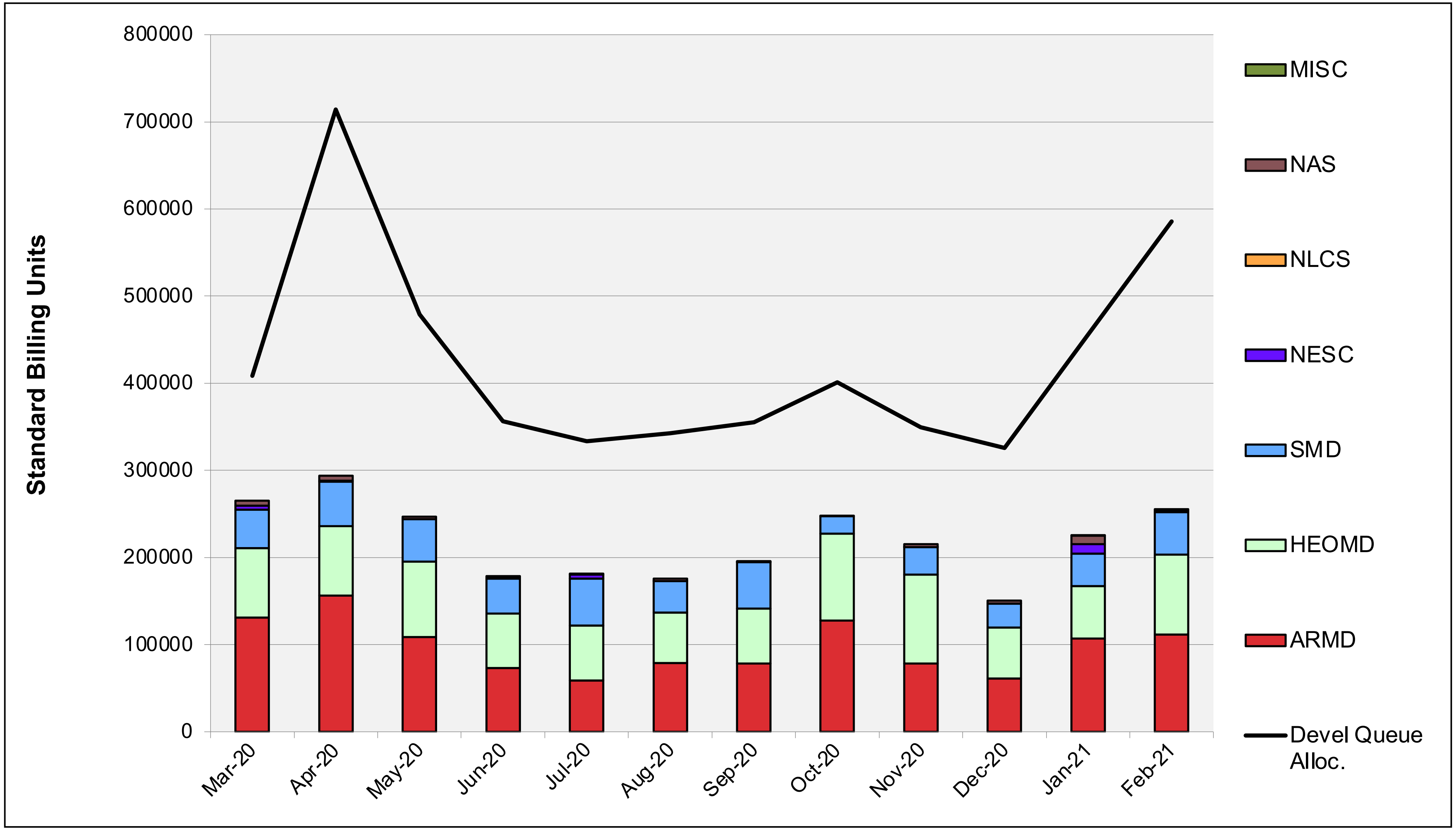


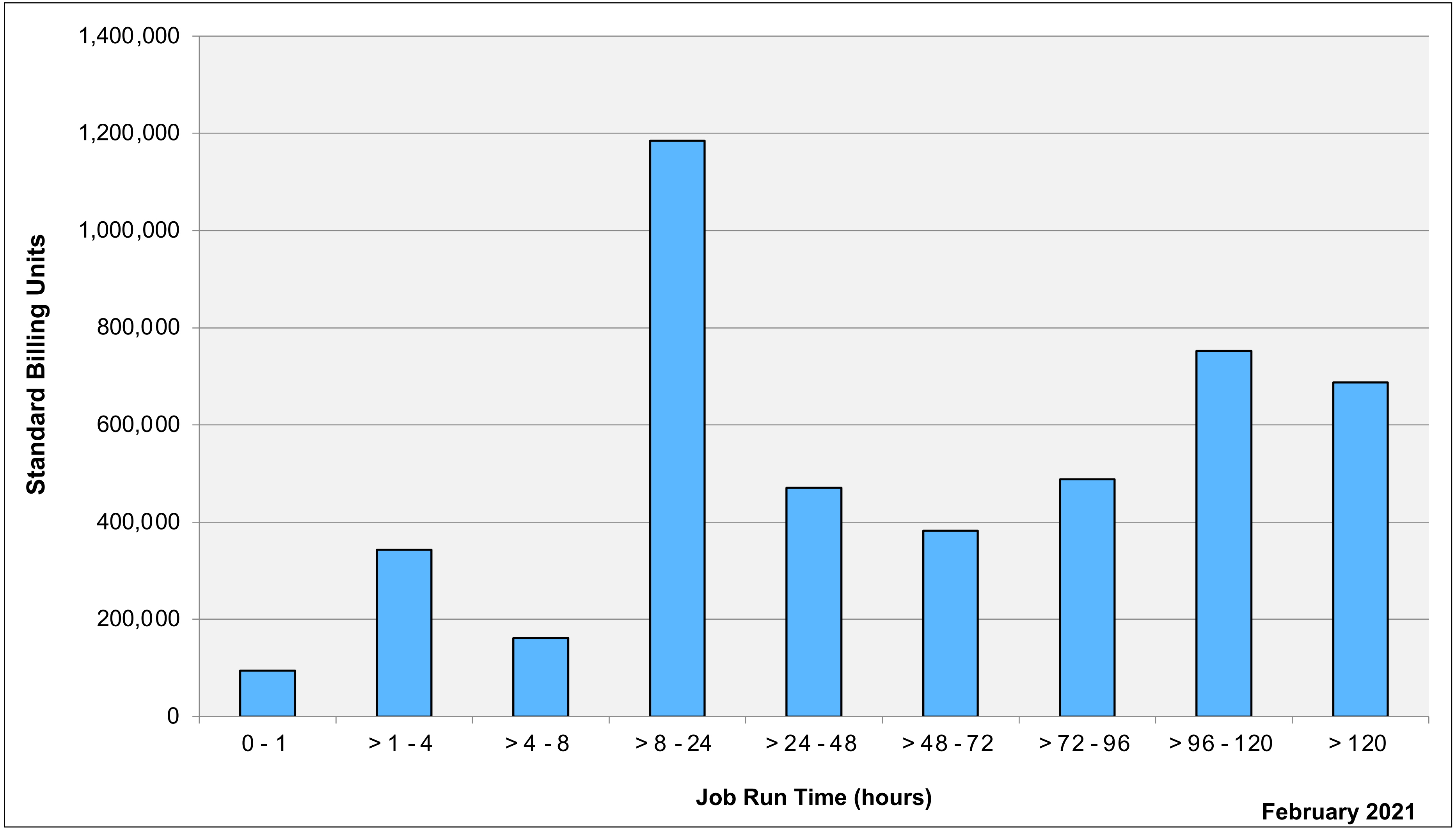
Pleiades: SBUs Reported, Normalized to 30-Day Month



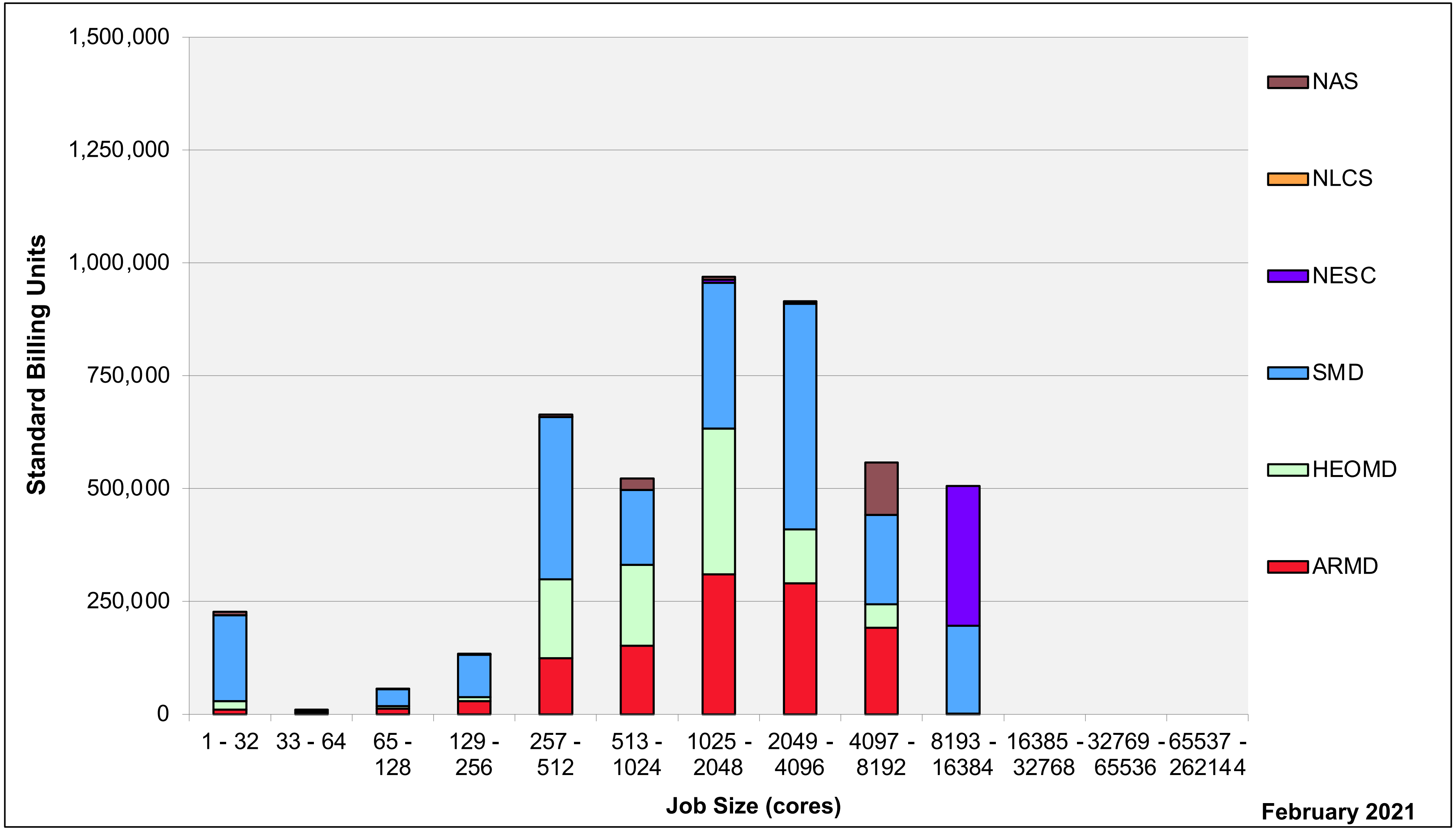
Pleiades: Devel Queue Utilization



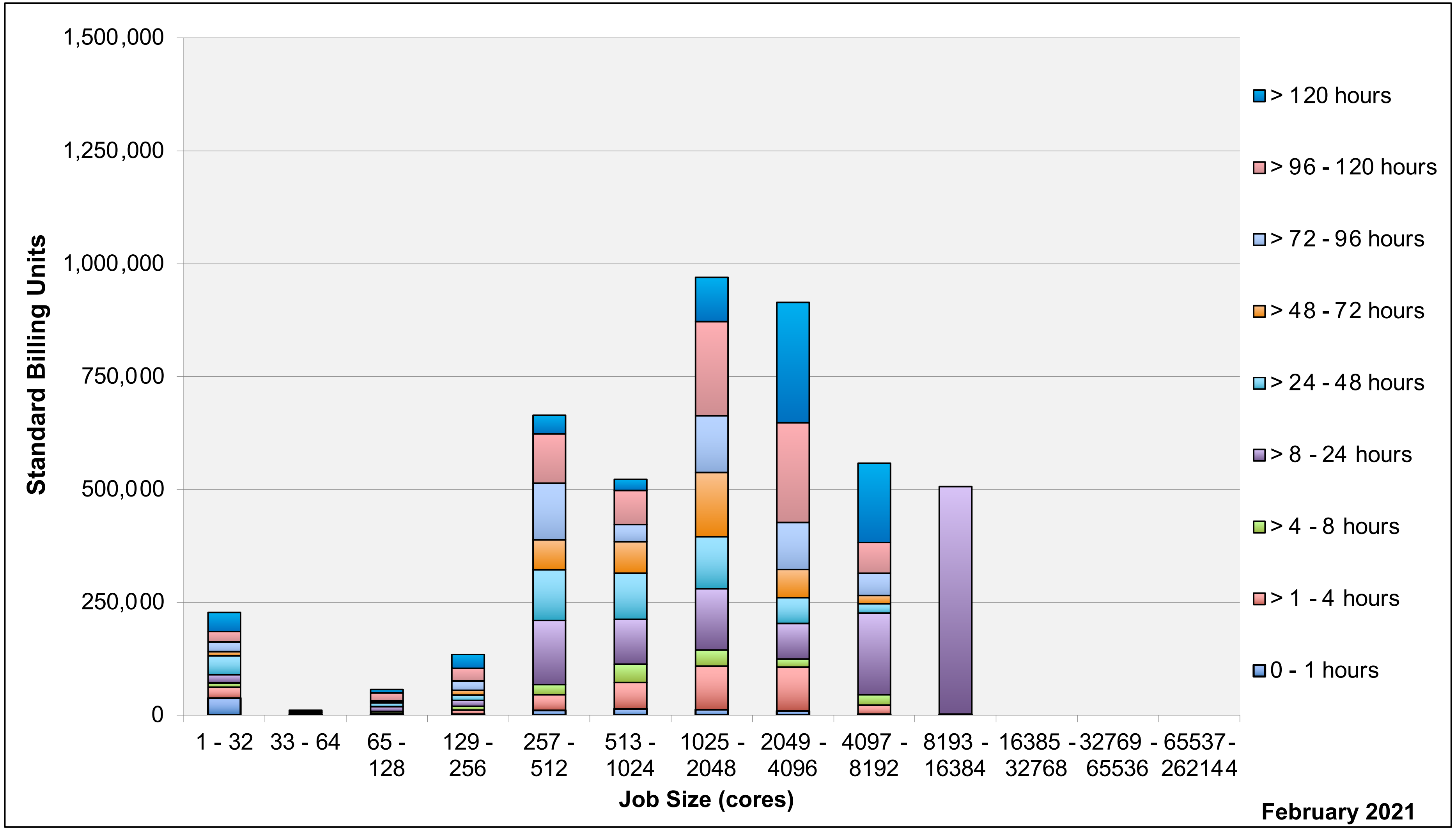
Pleiades: Monthly Utilization by Job Length



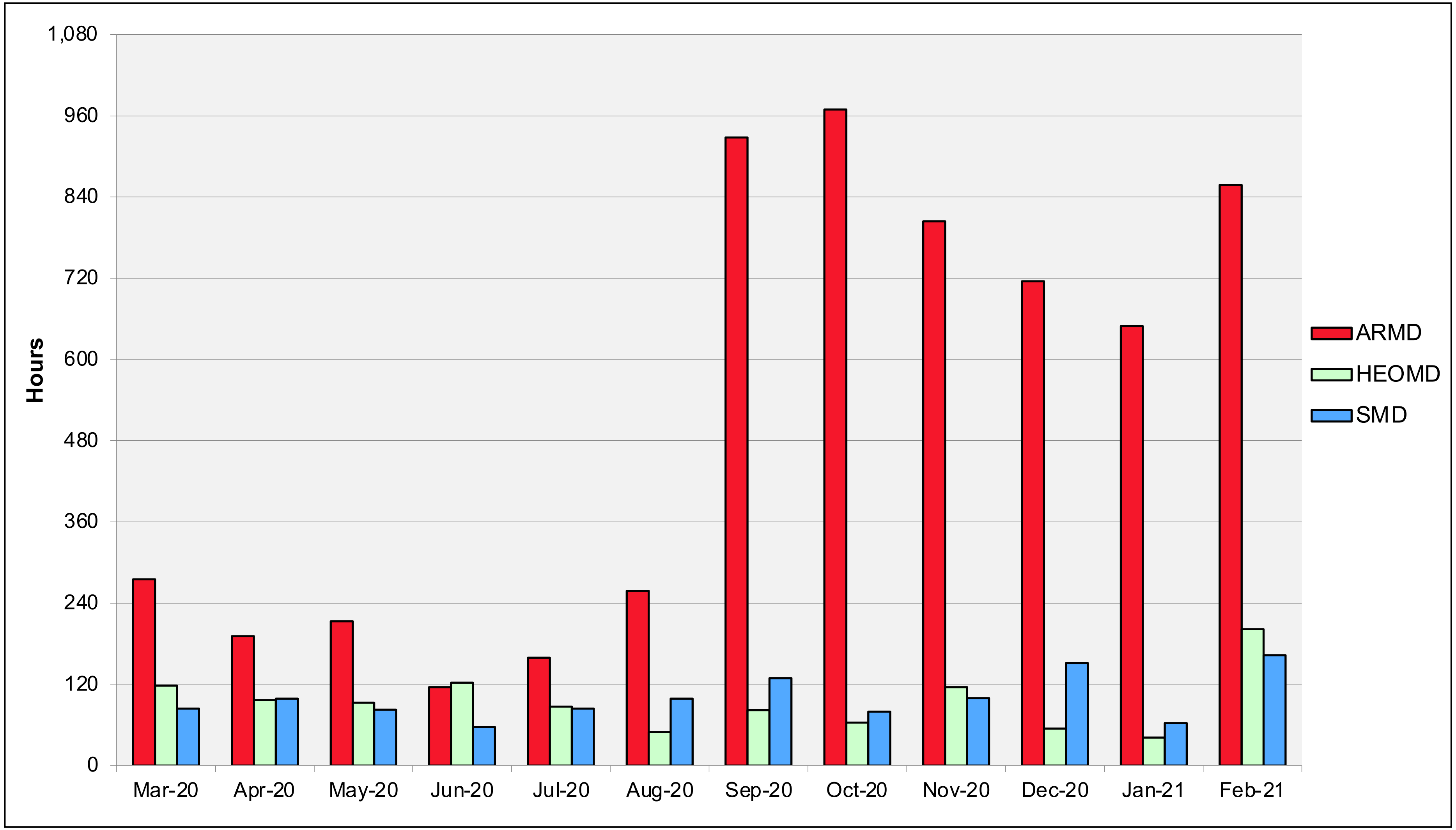
Pleiades: Monthly Utilization by Job Size



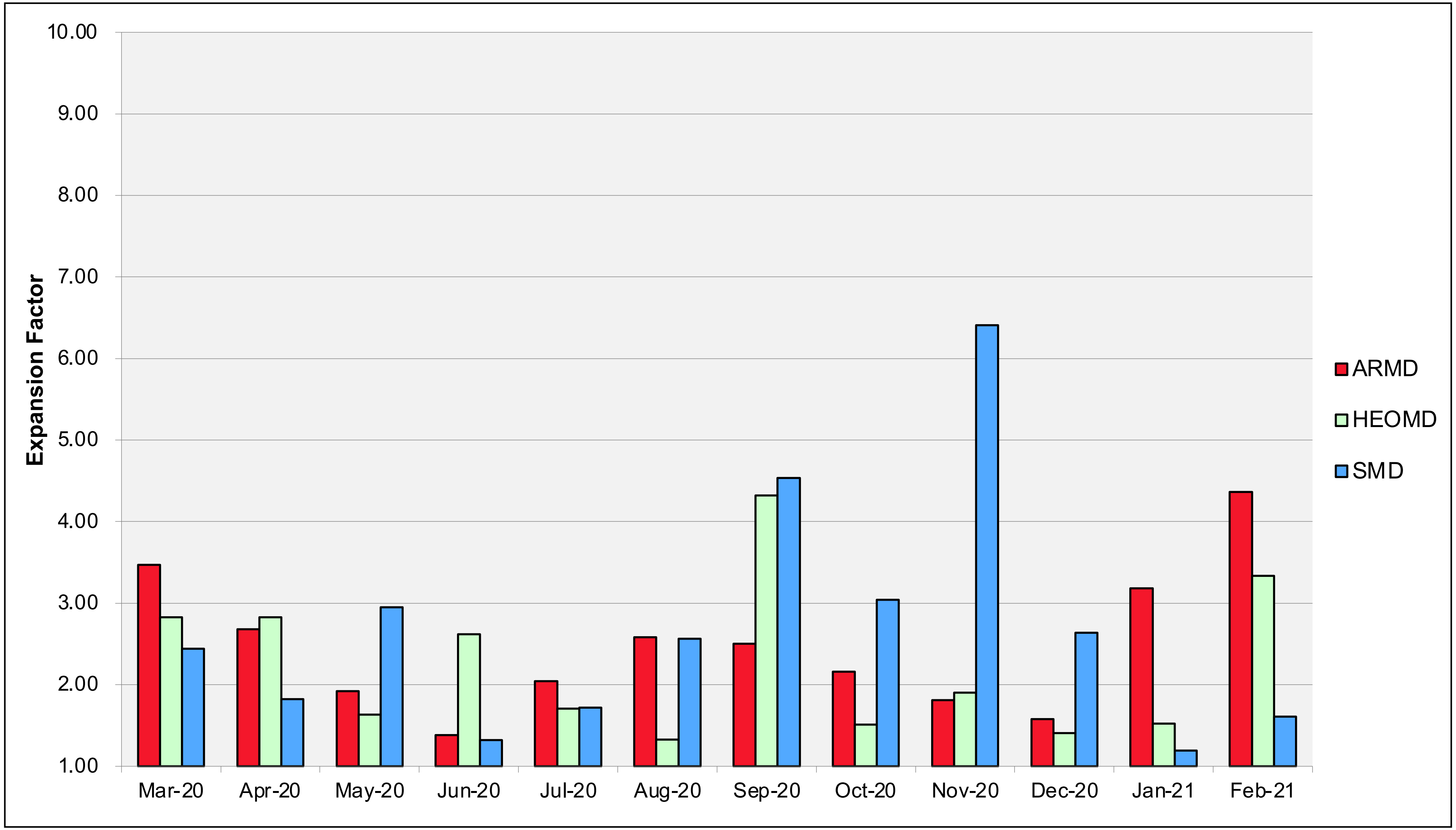
Pleiades: Monthly Utilization by Size and Length



Pleiades: Average Time to Clear All Jobs



Pleiades: Average Expansion Factor



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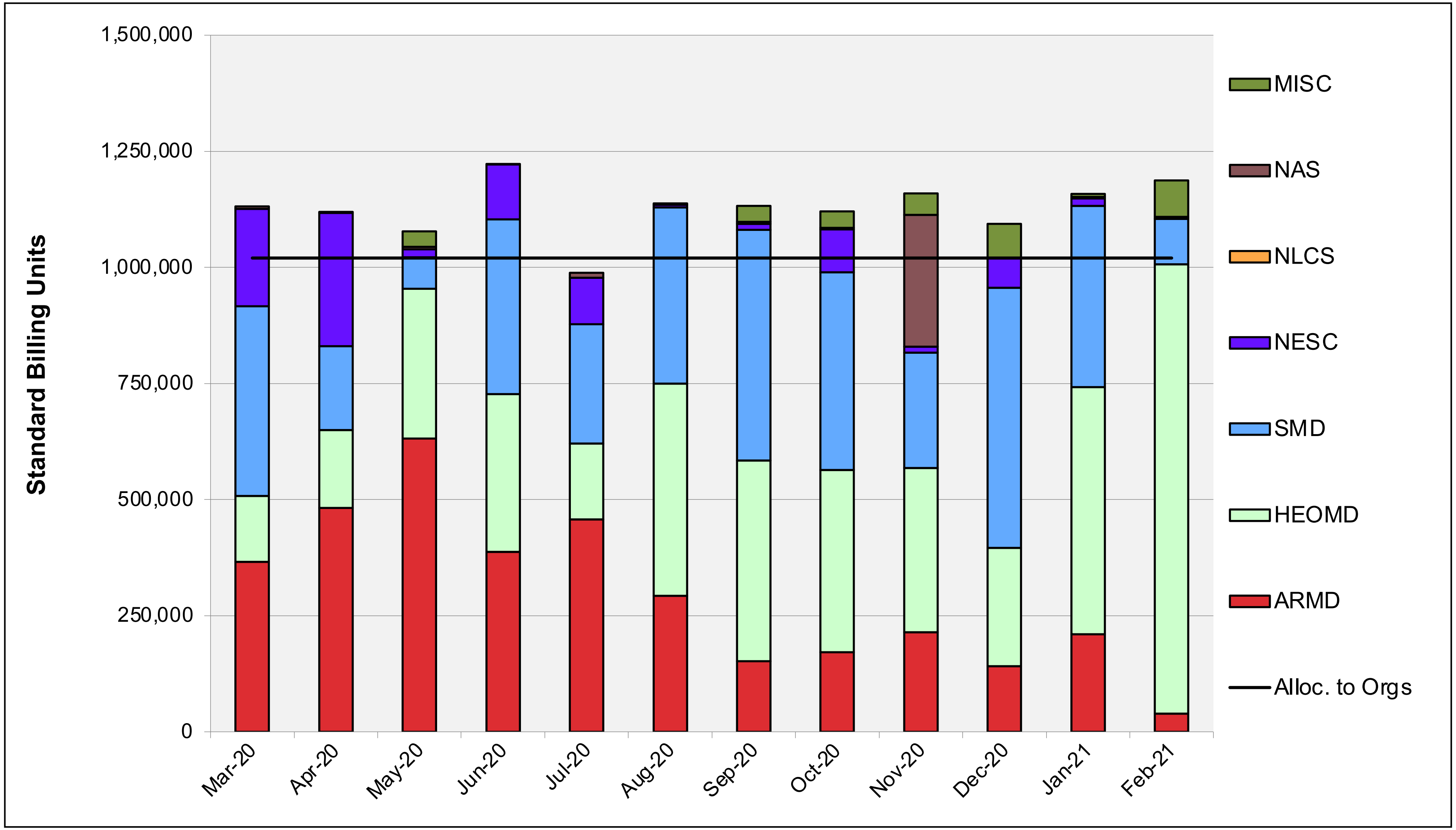

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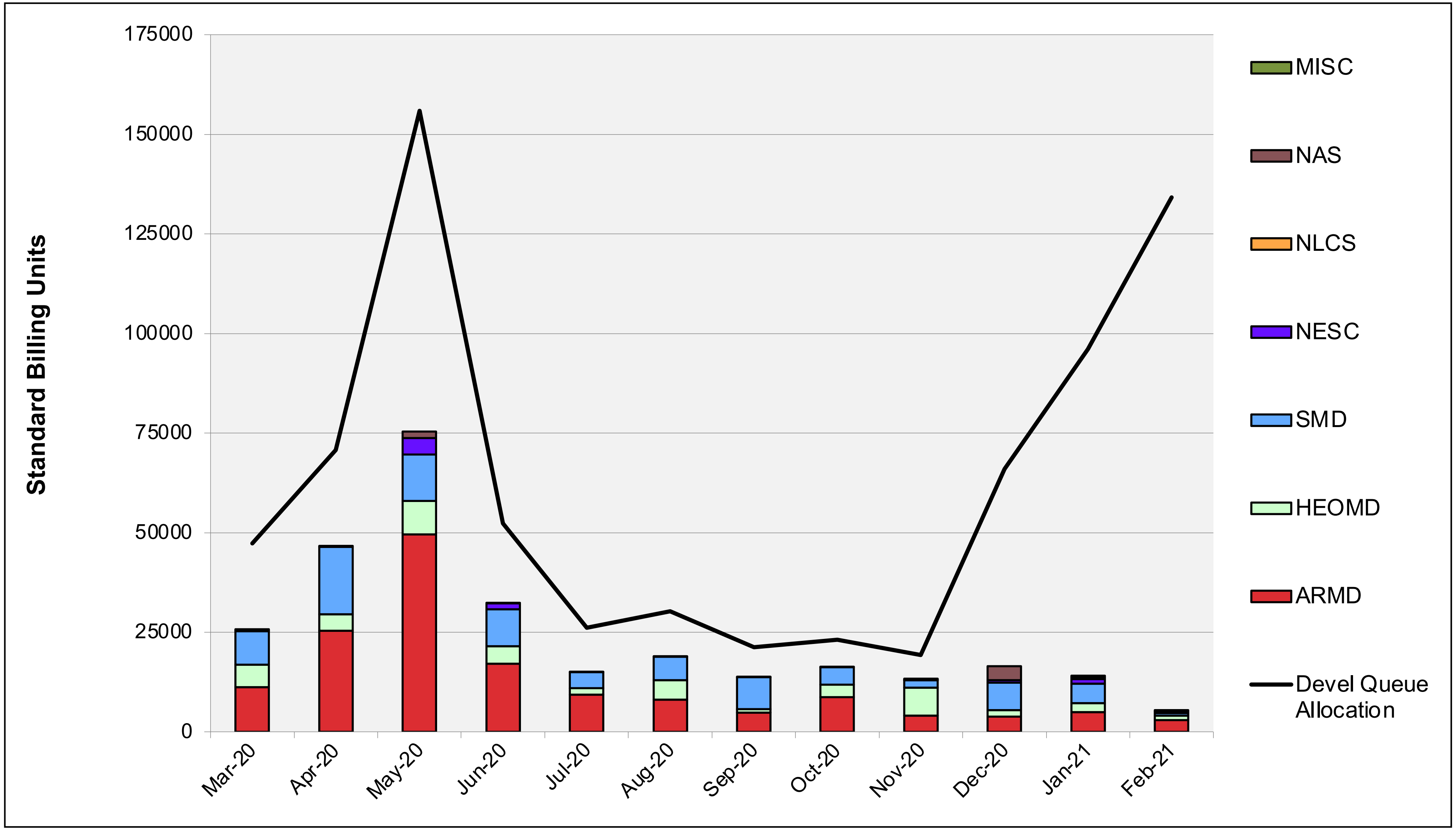
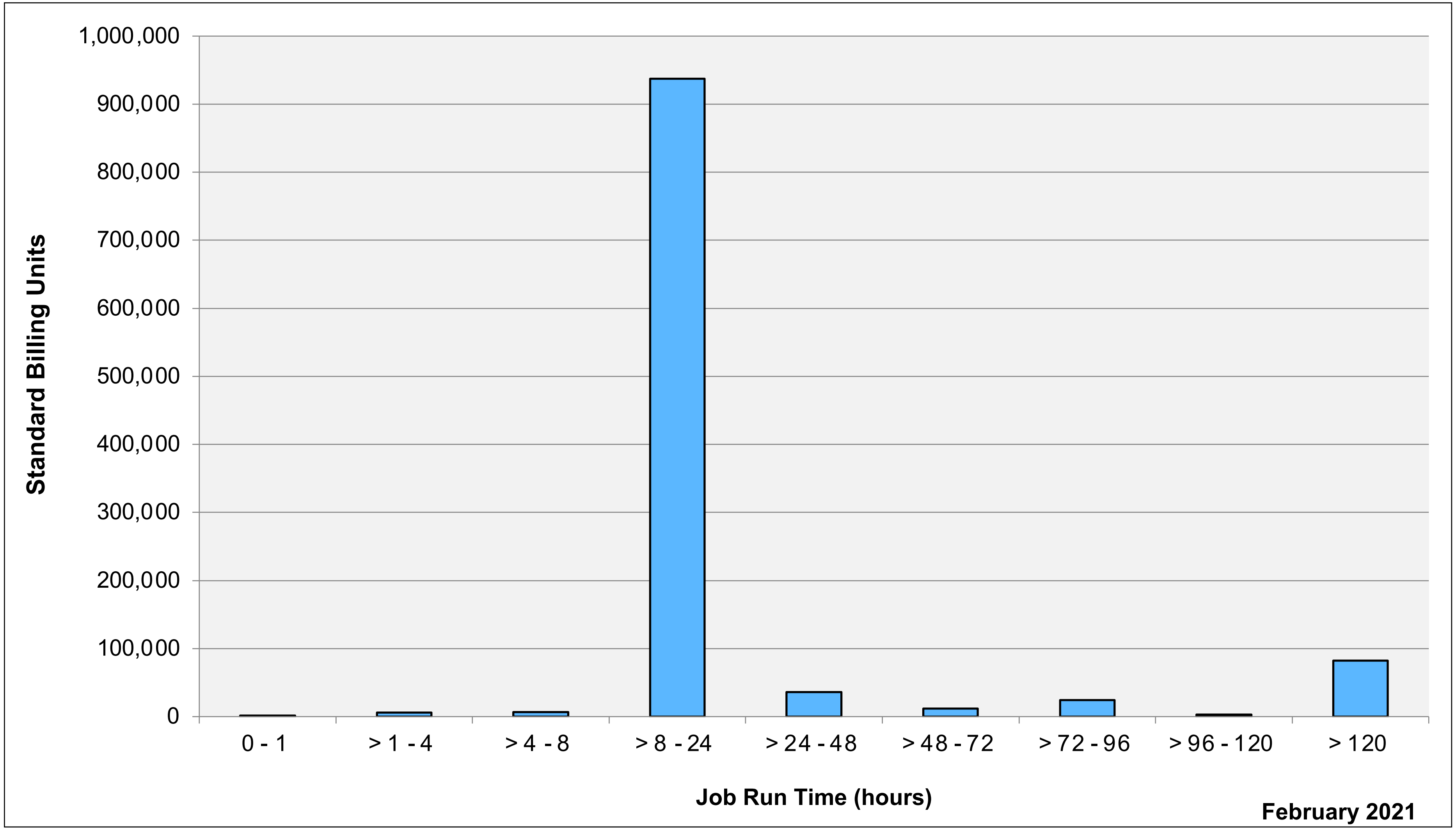


Aitken: Monthly Utilization by Job Length



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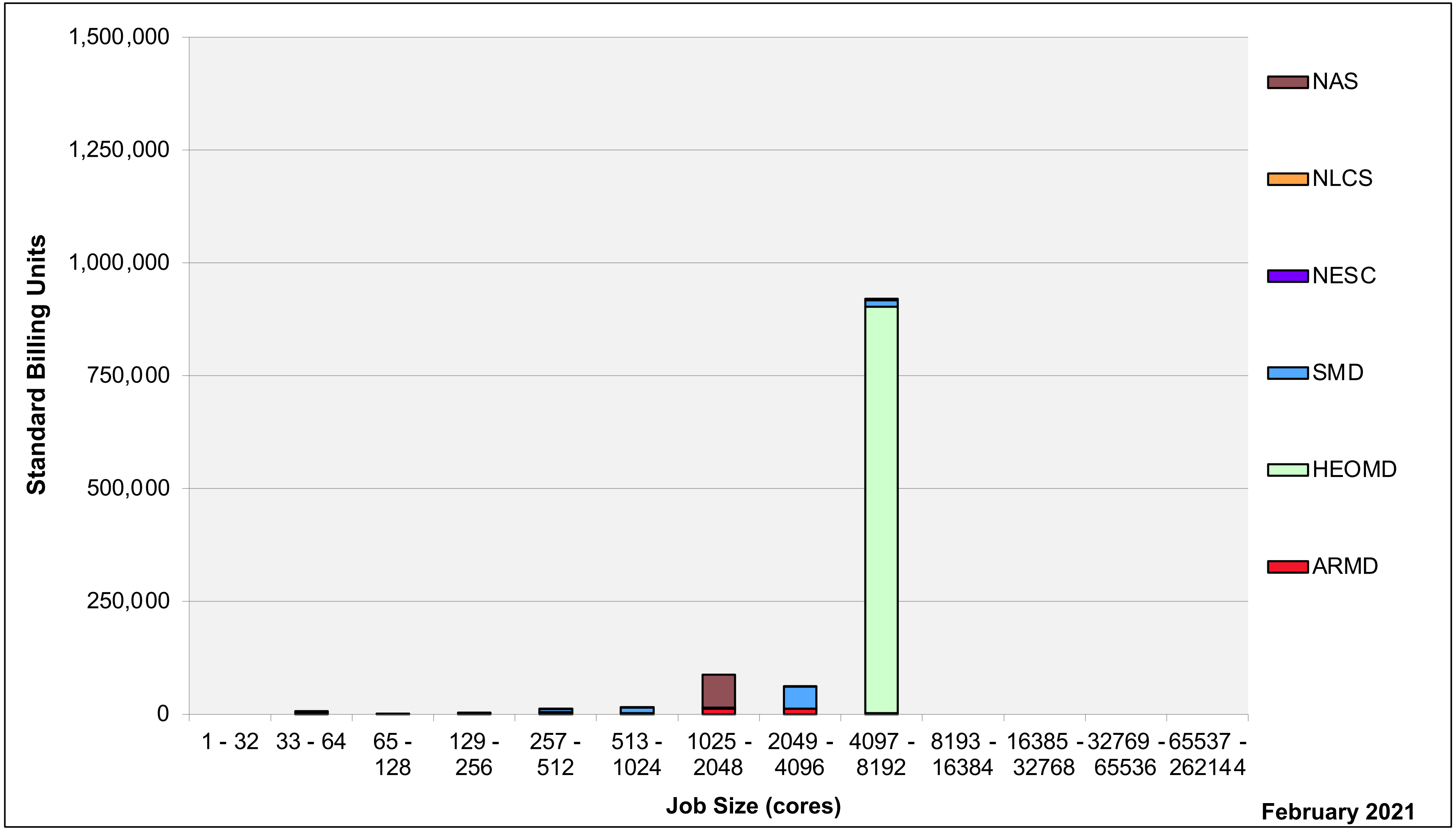

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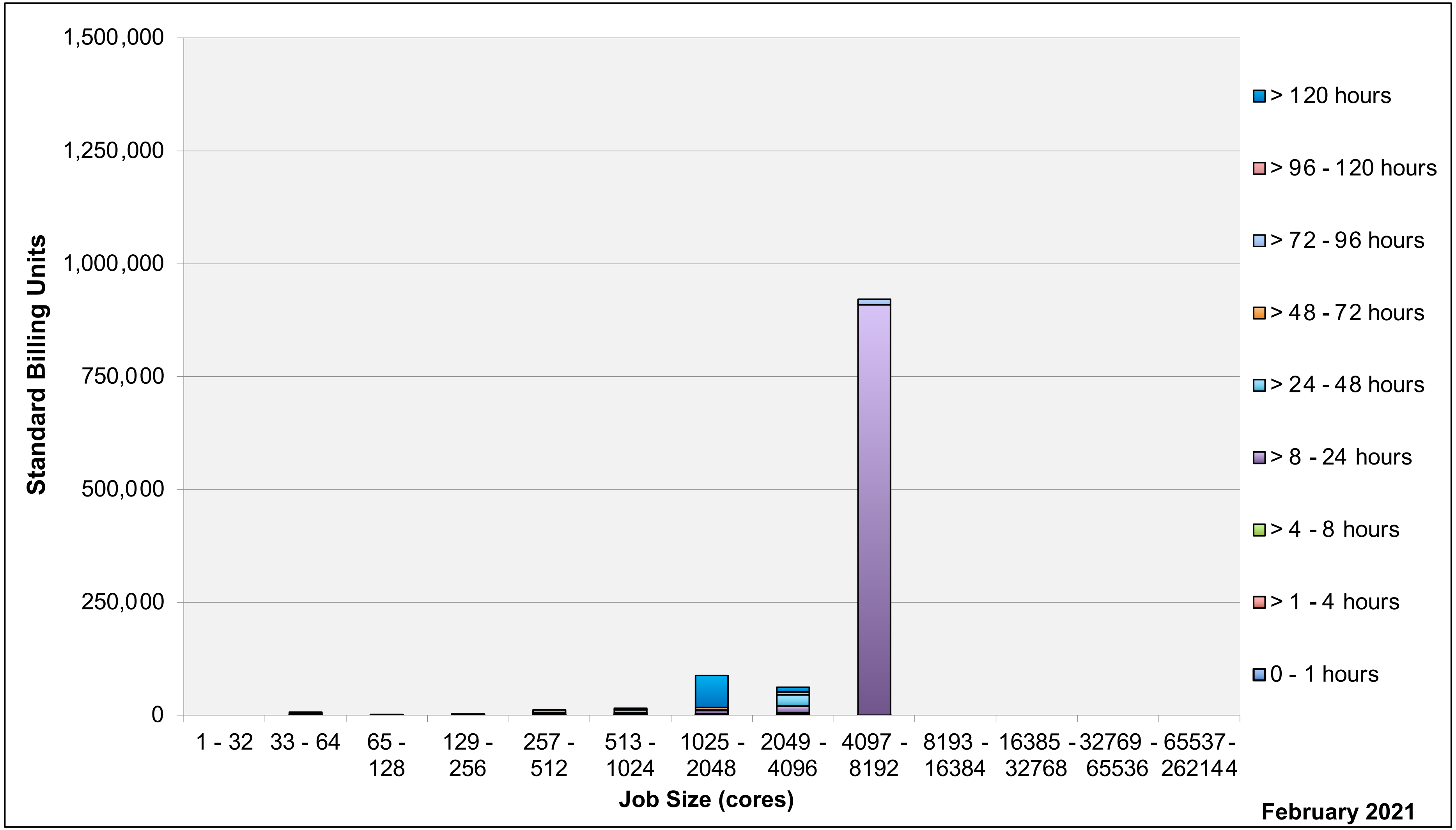

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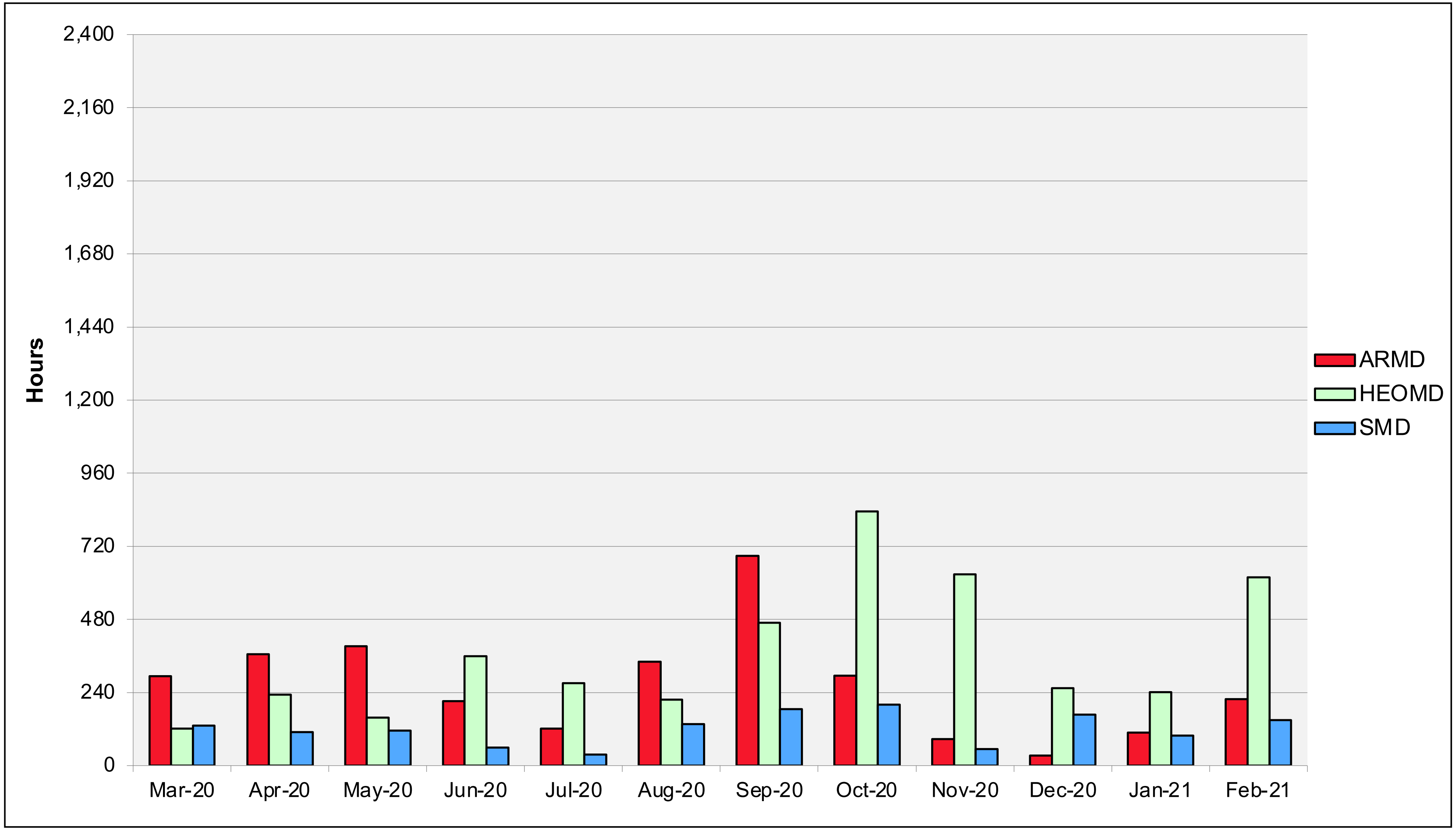

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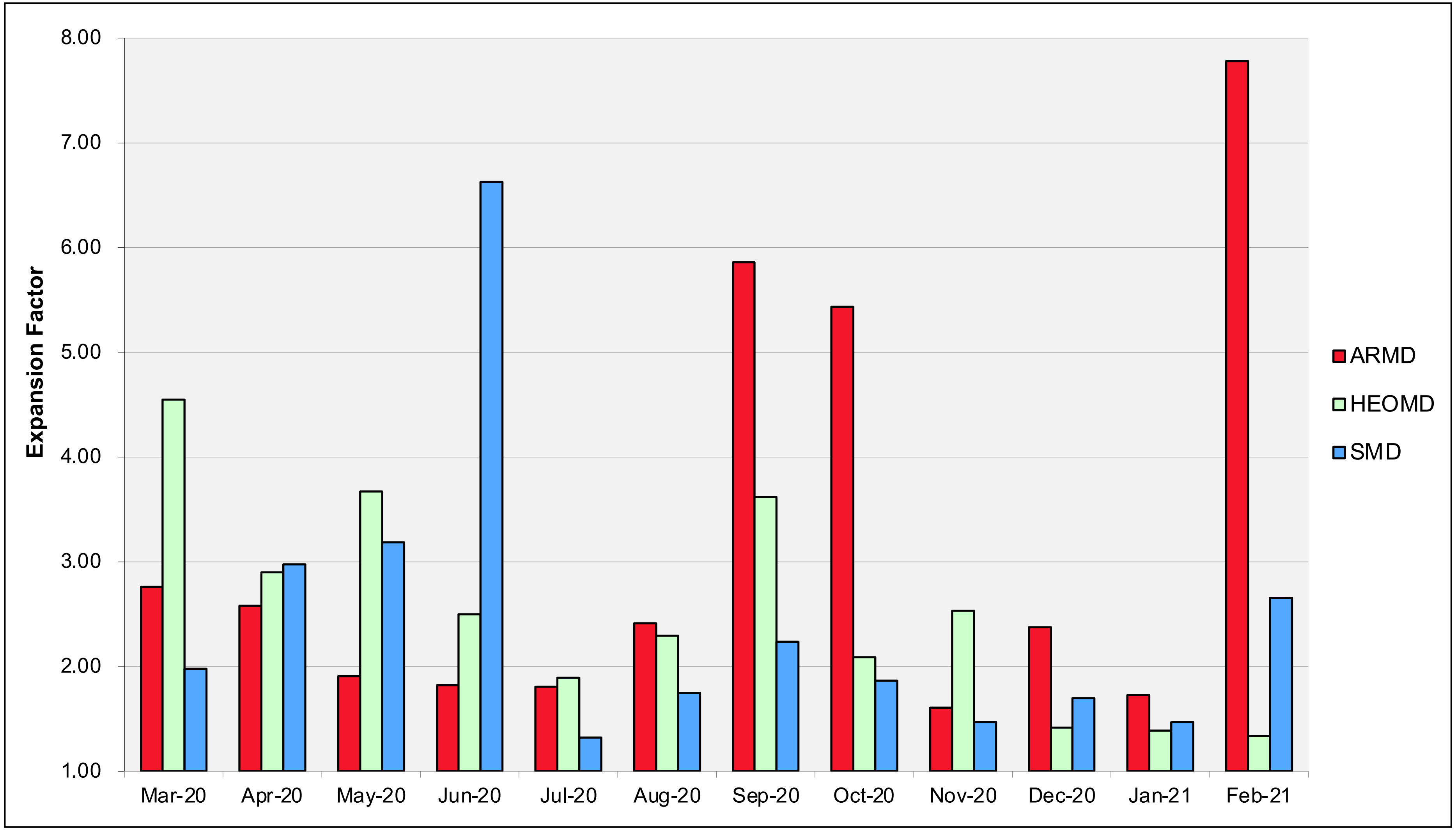
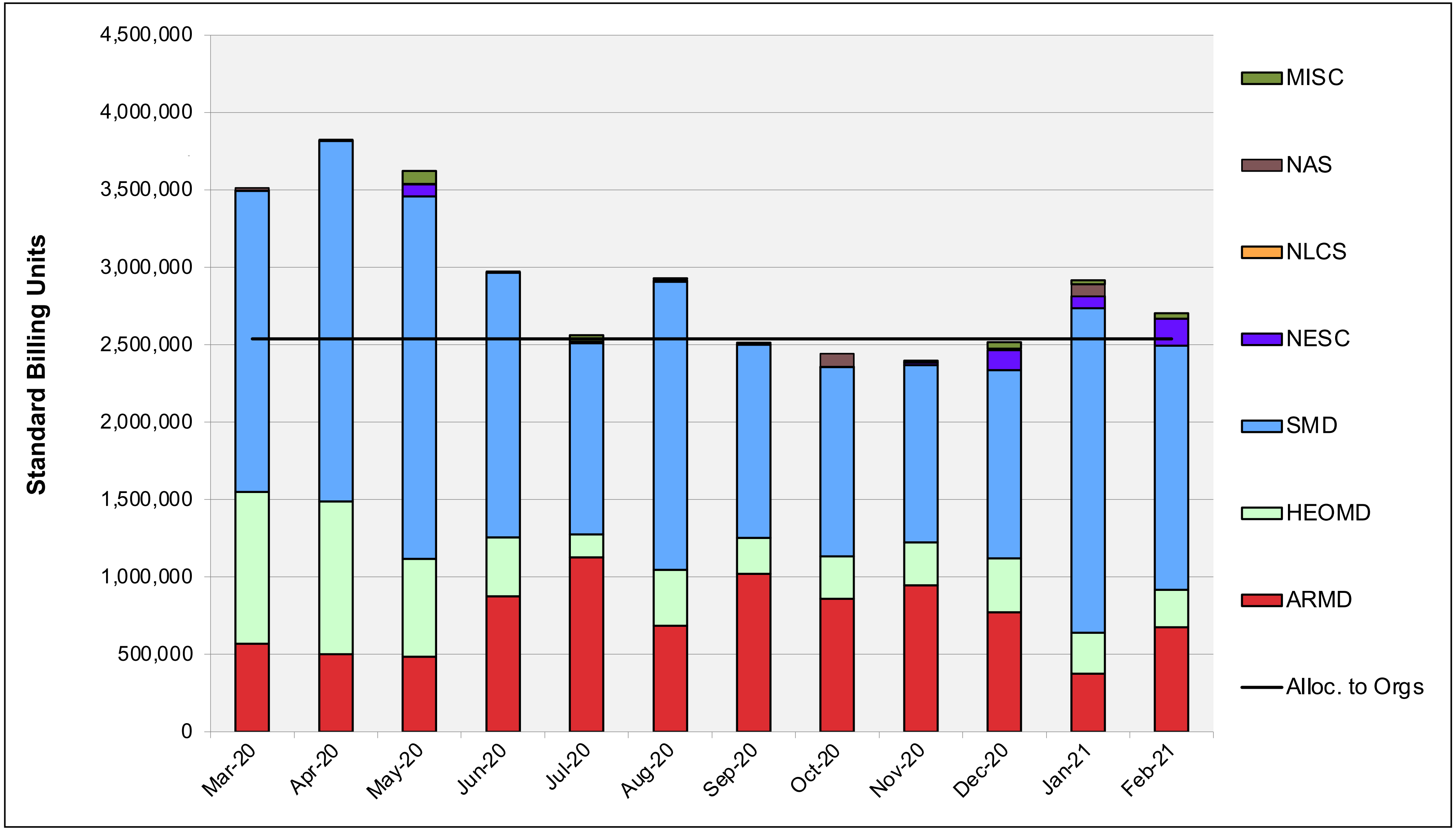


Electra: SBUs Reported, Normalized to 30-Day Month



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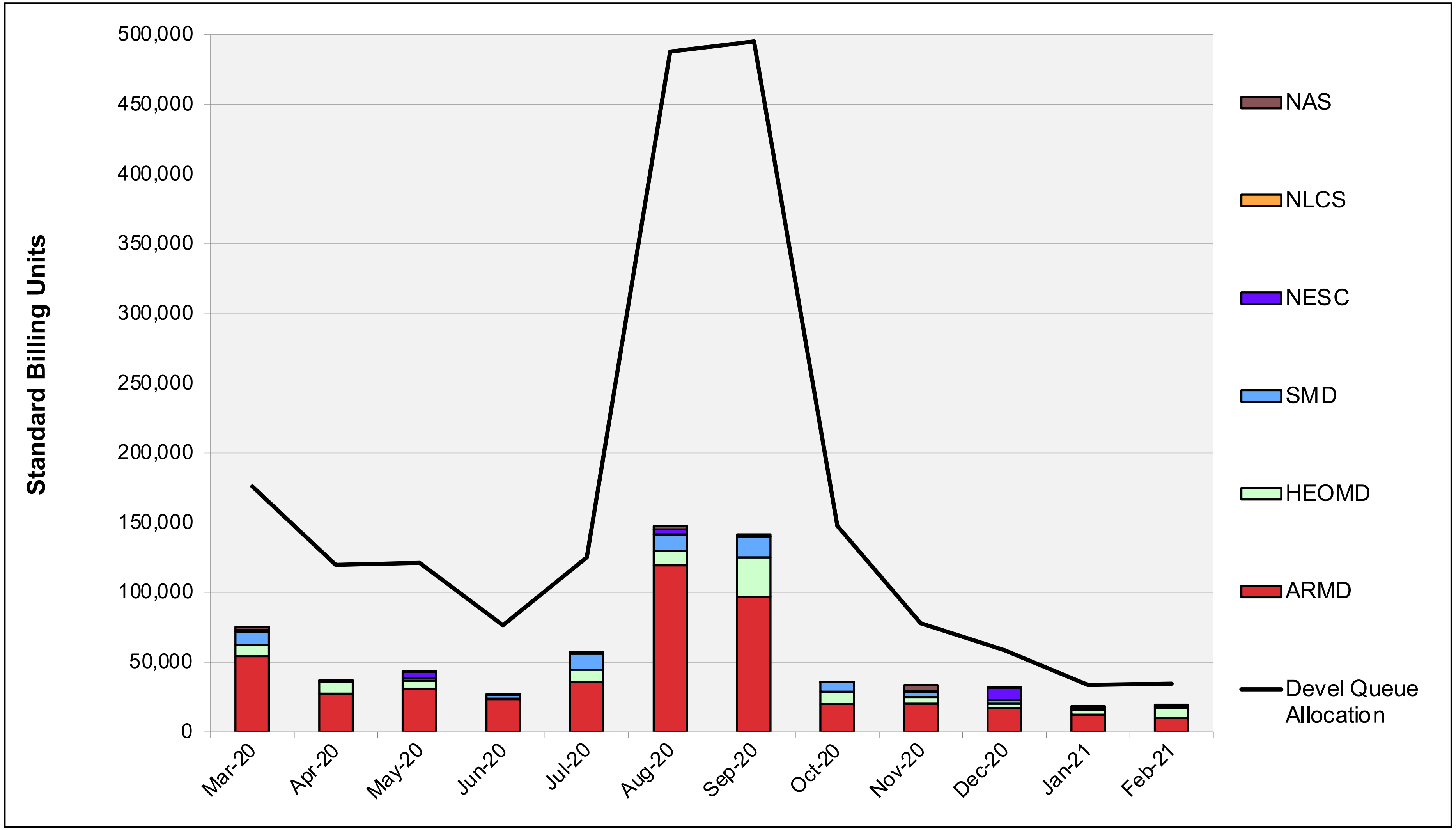
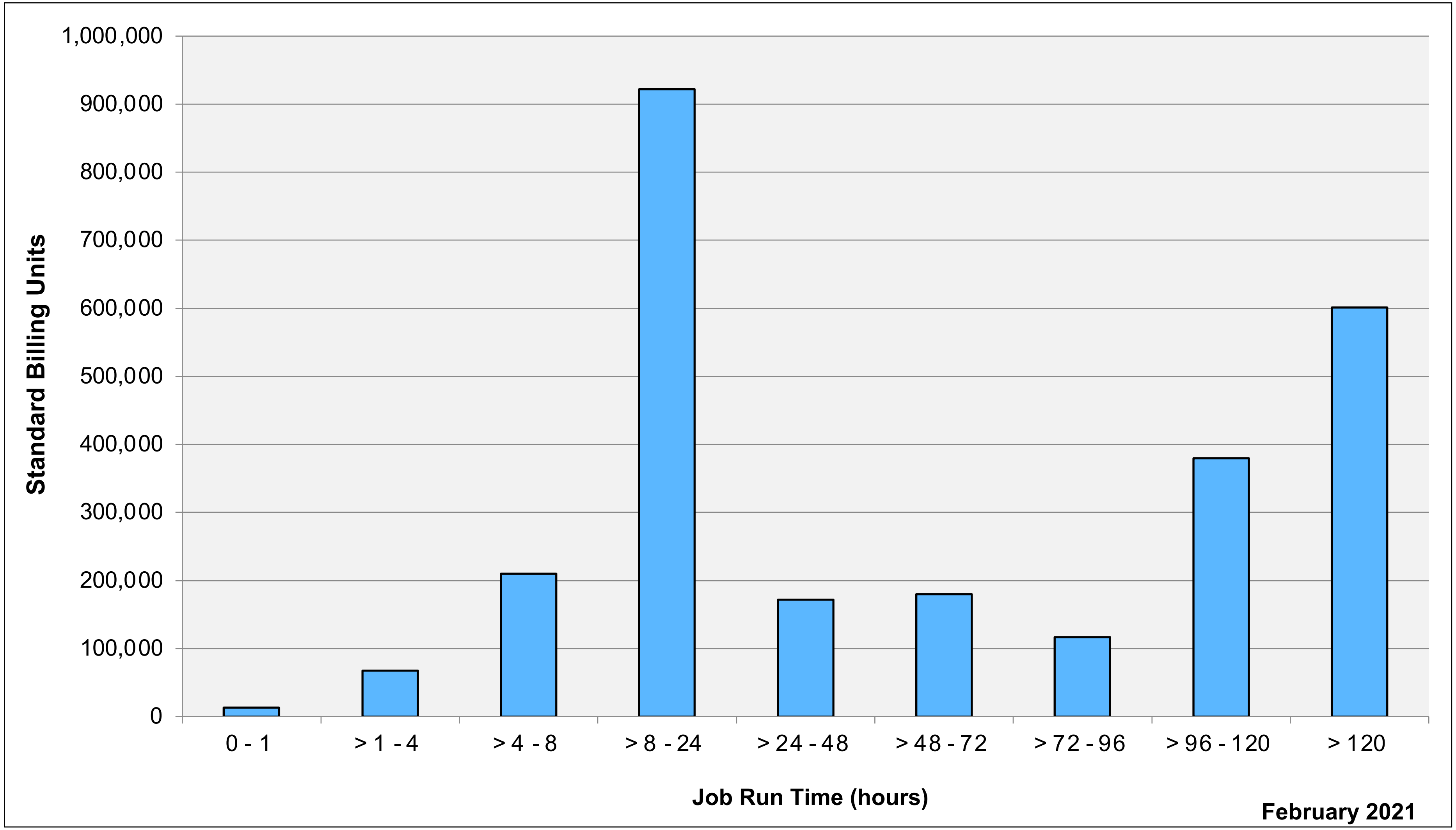


Electra: Monthly Utilization by Job Length



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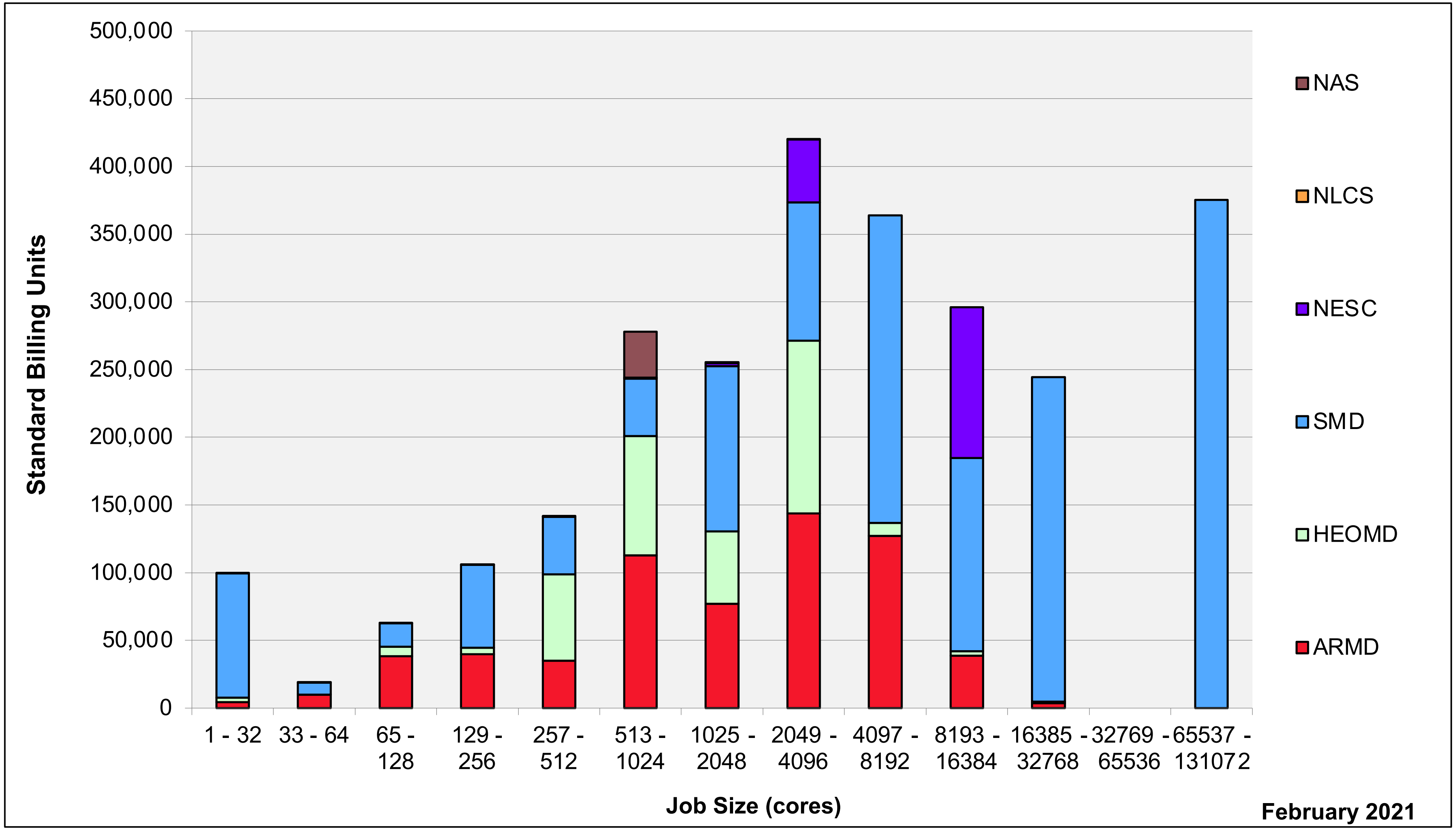

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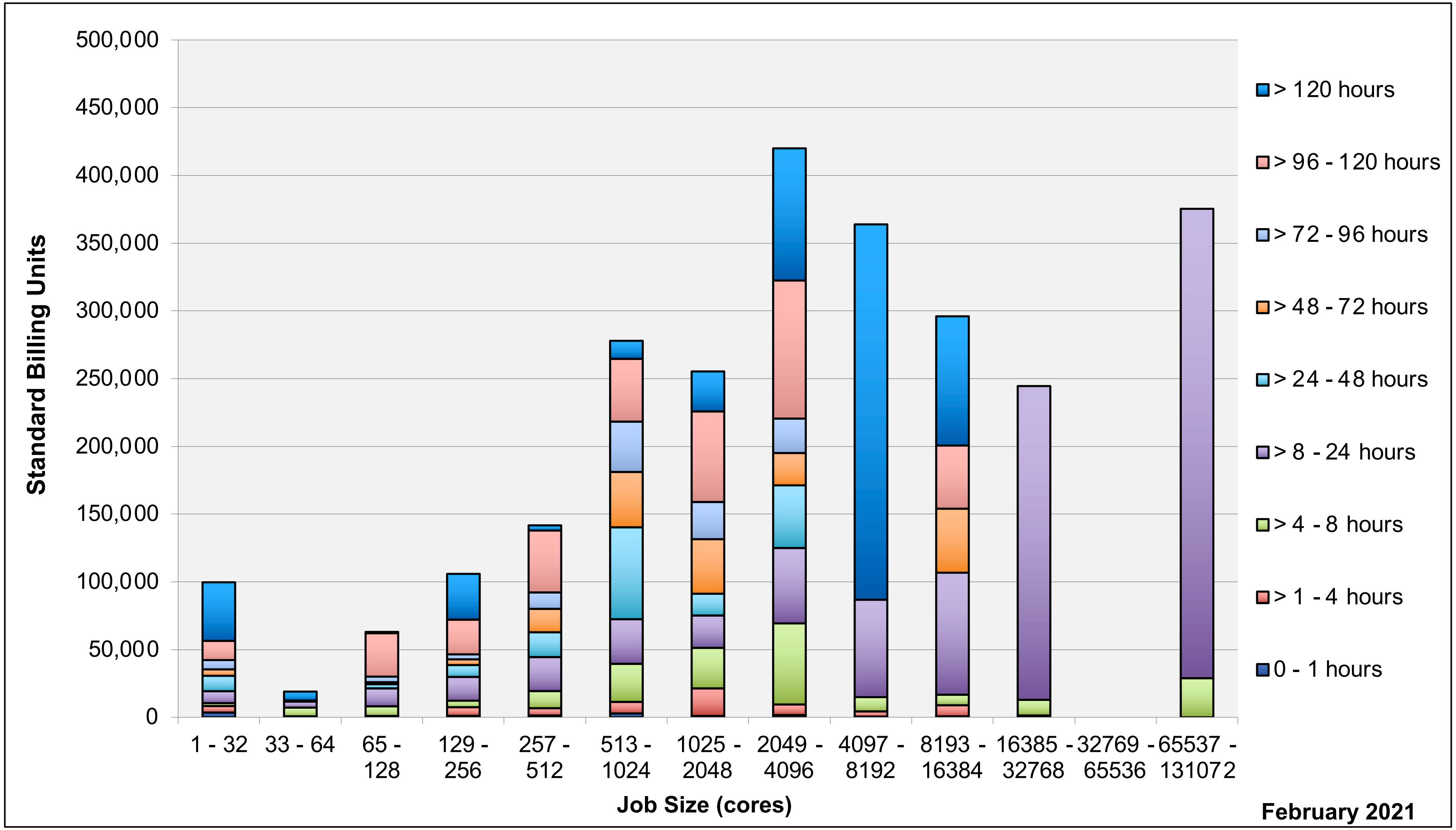

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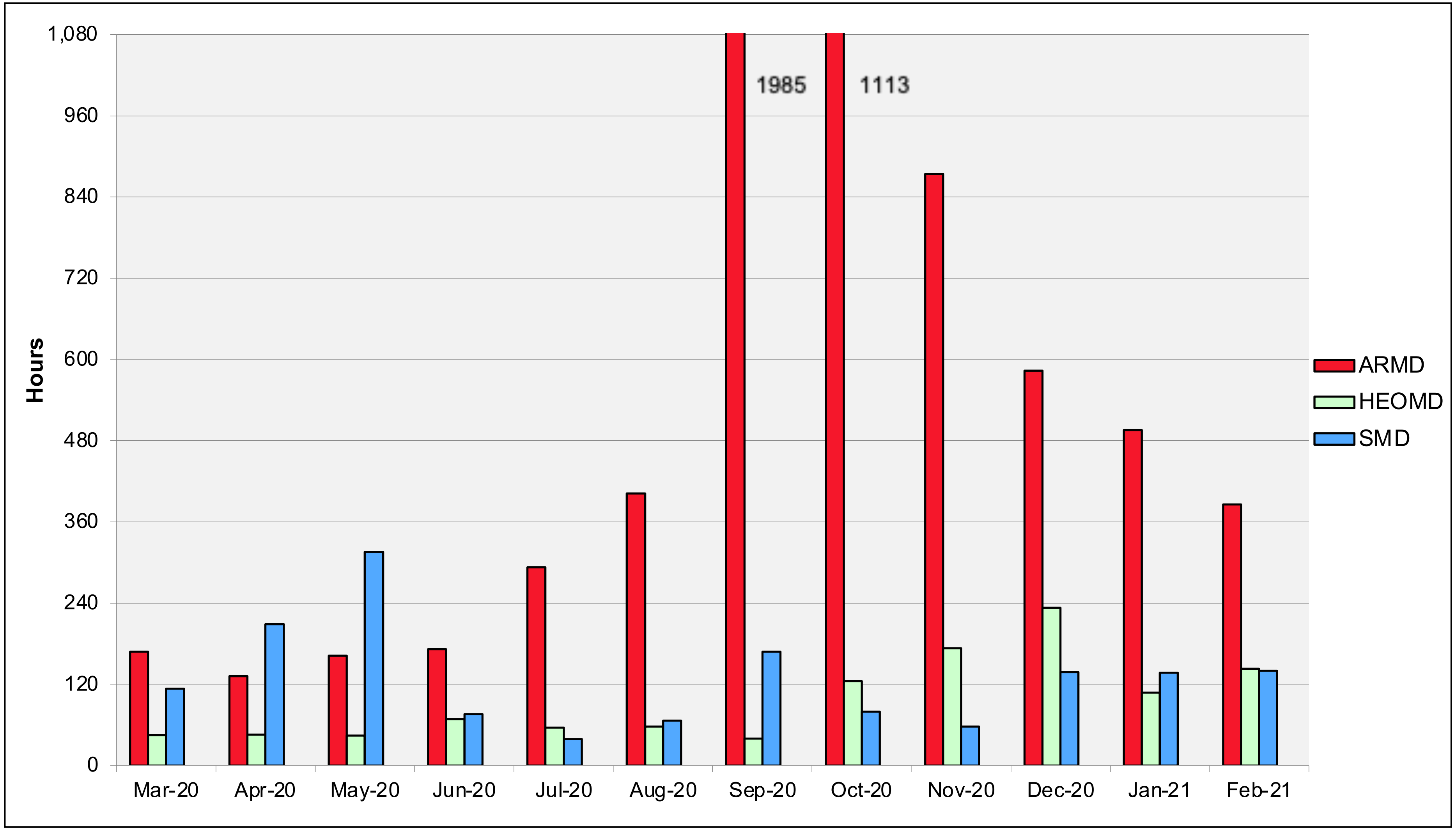

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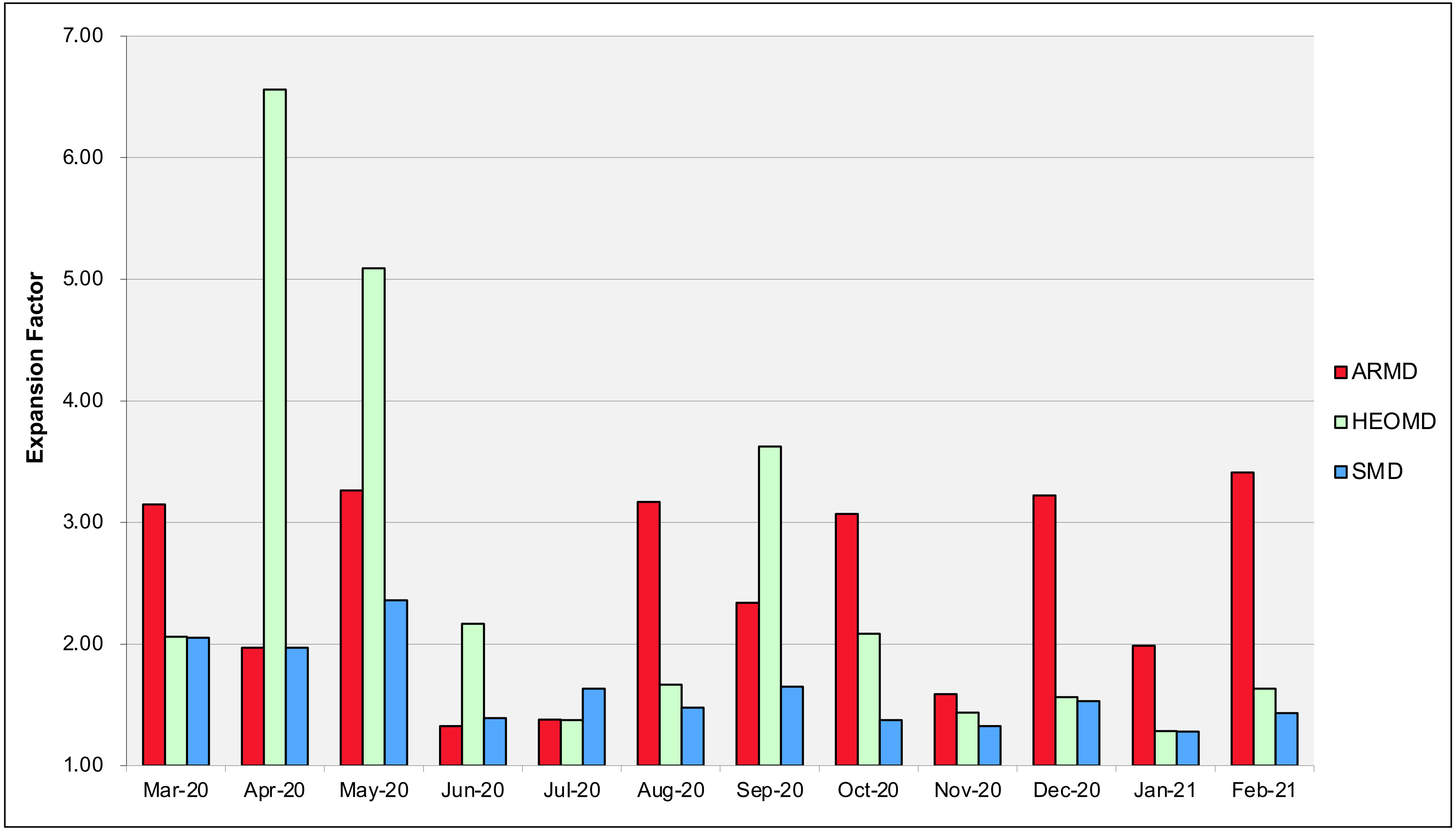

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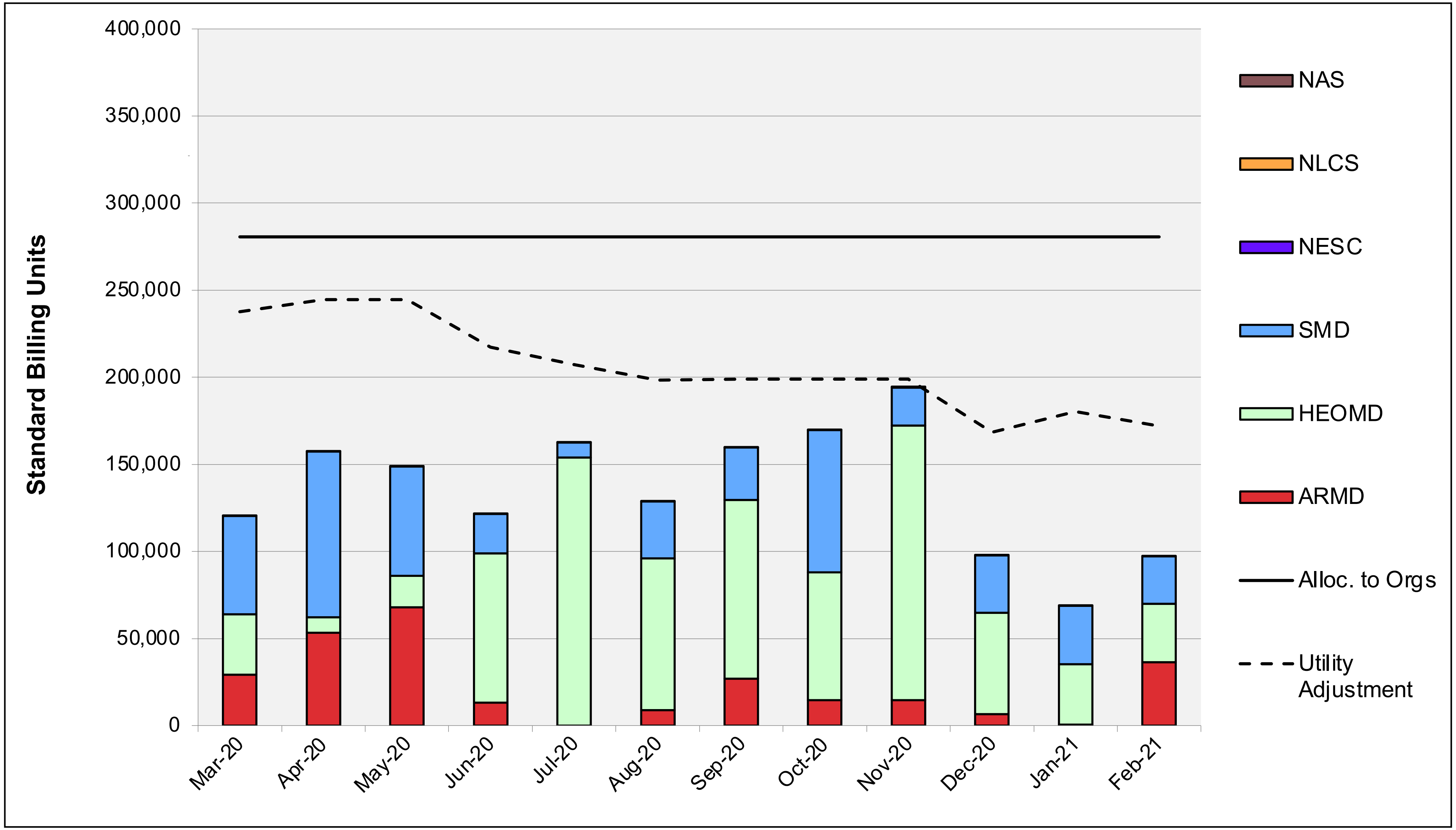
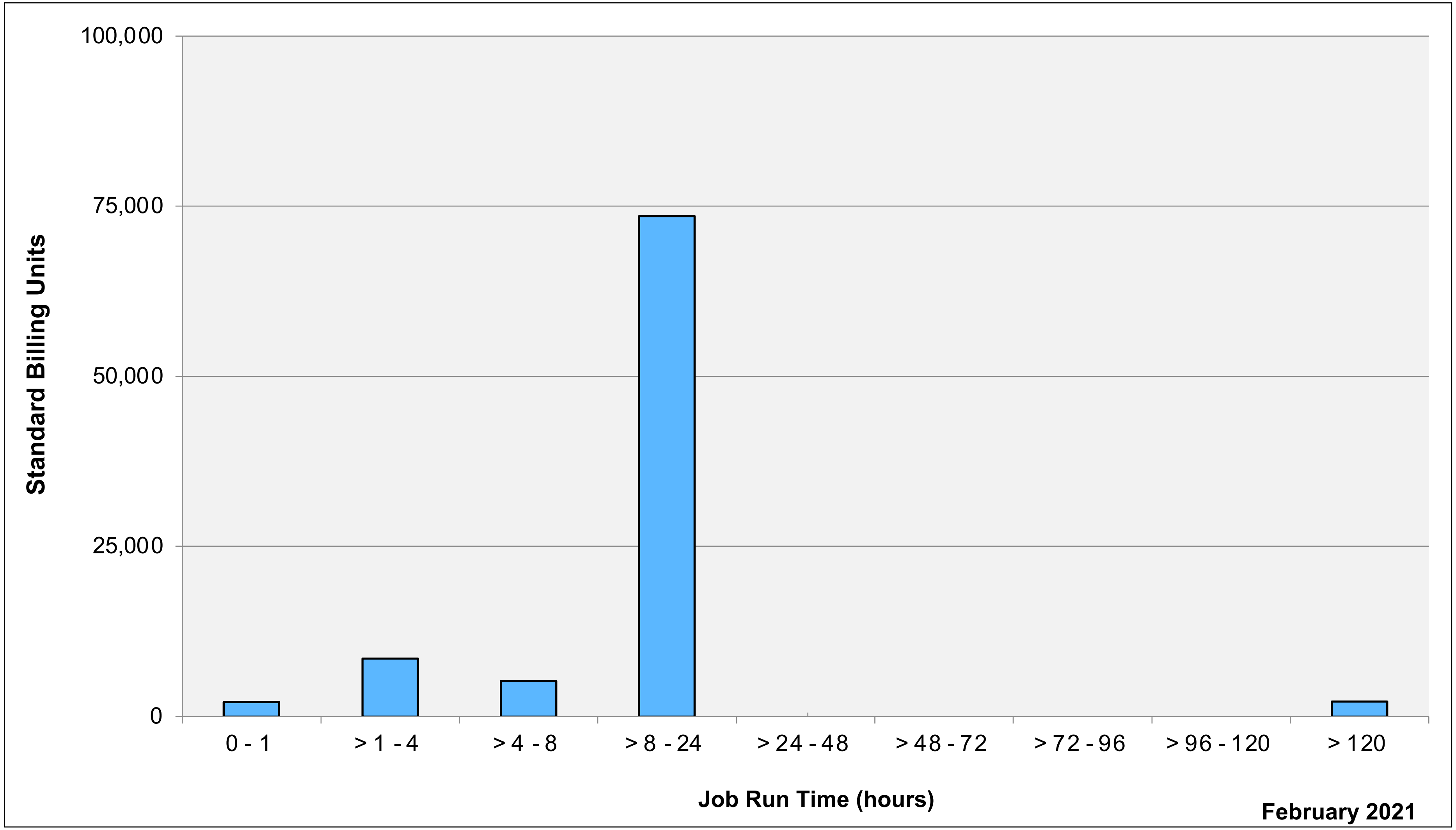
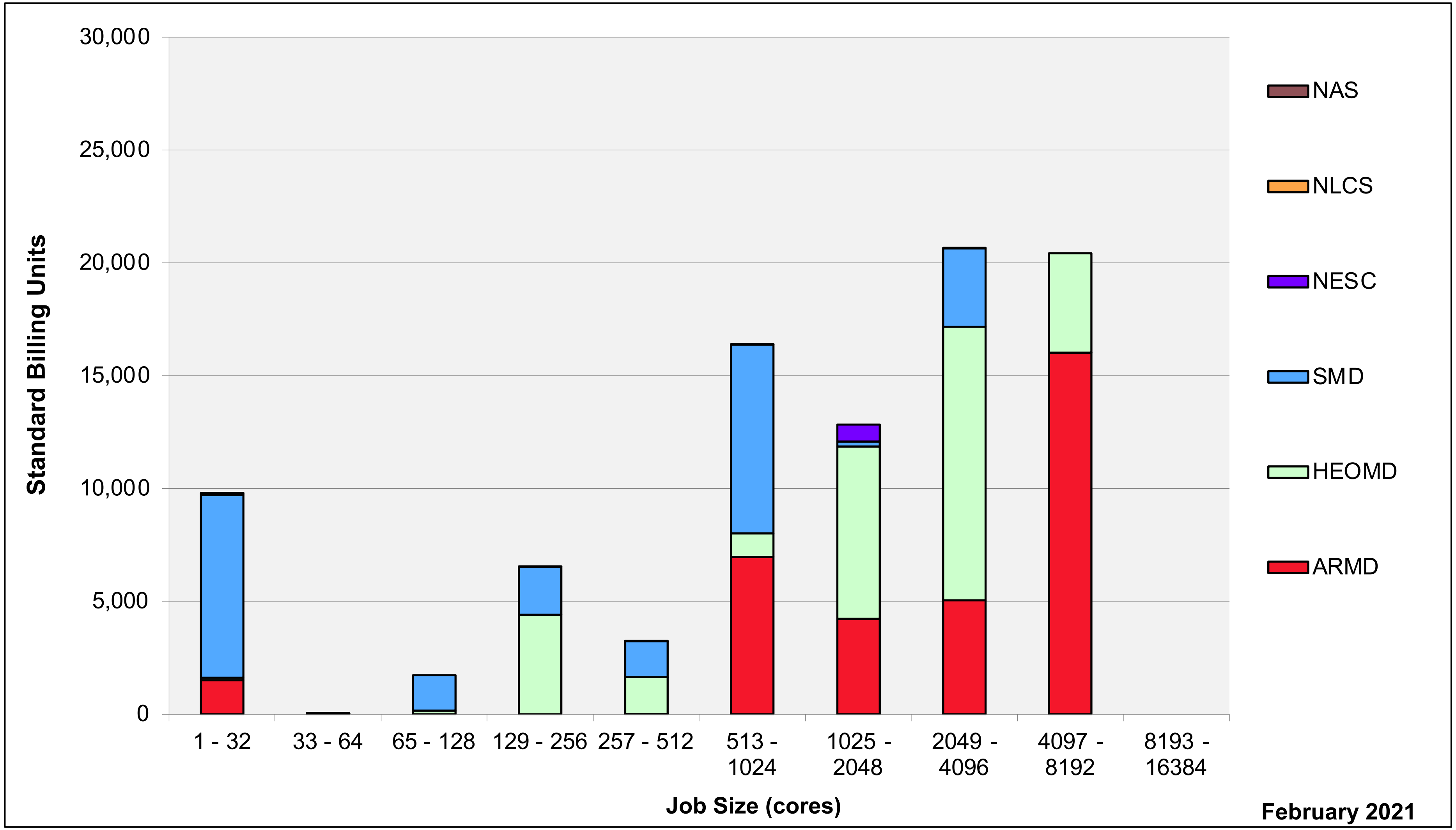


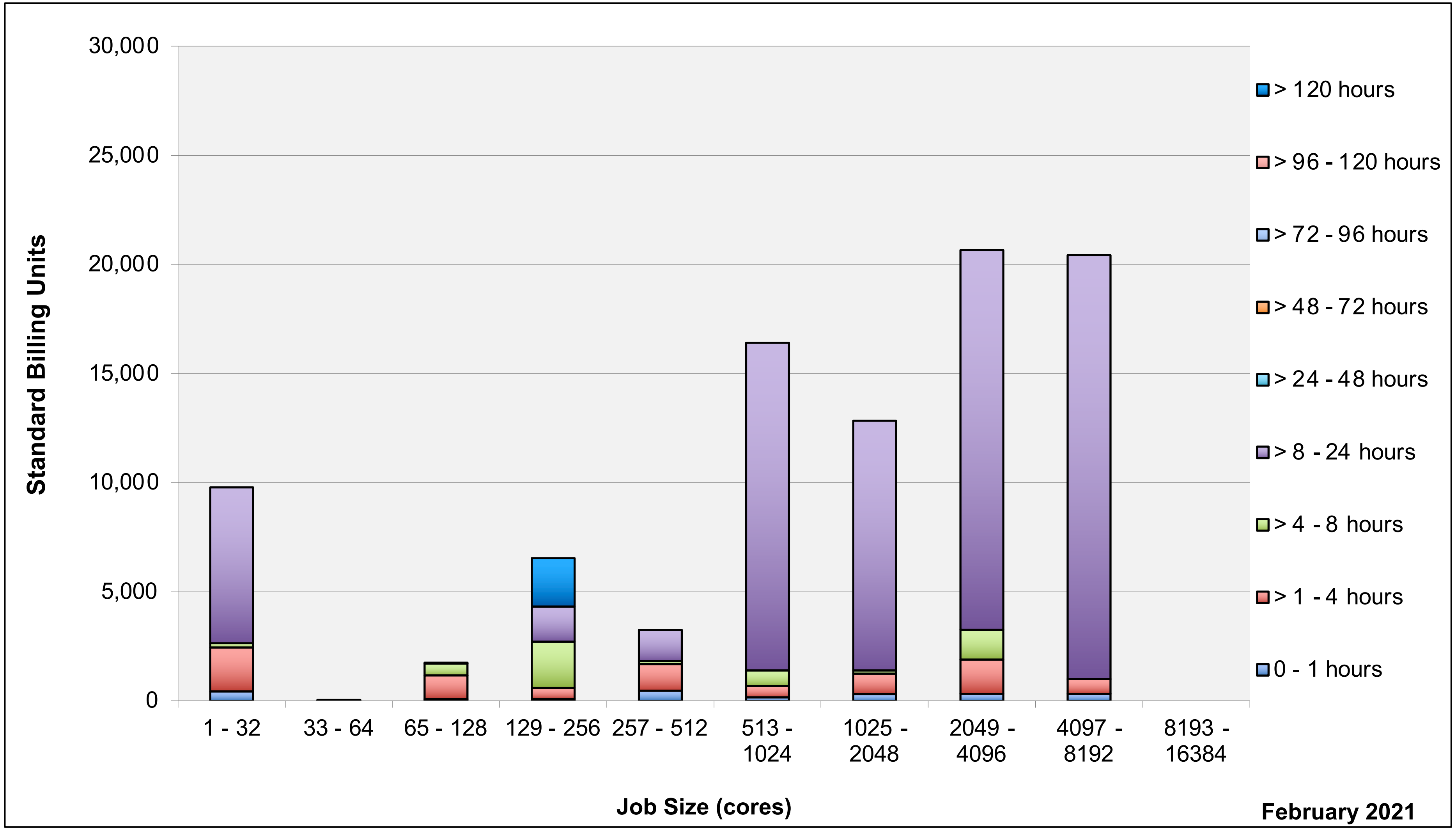
Merope: Monthly Utilization by Job Length



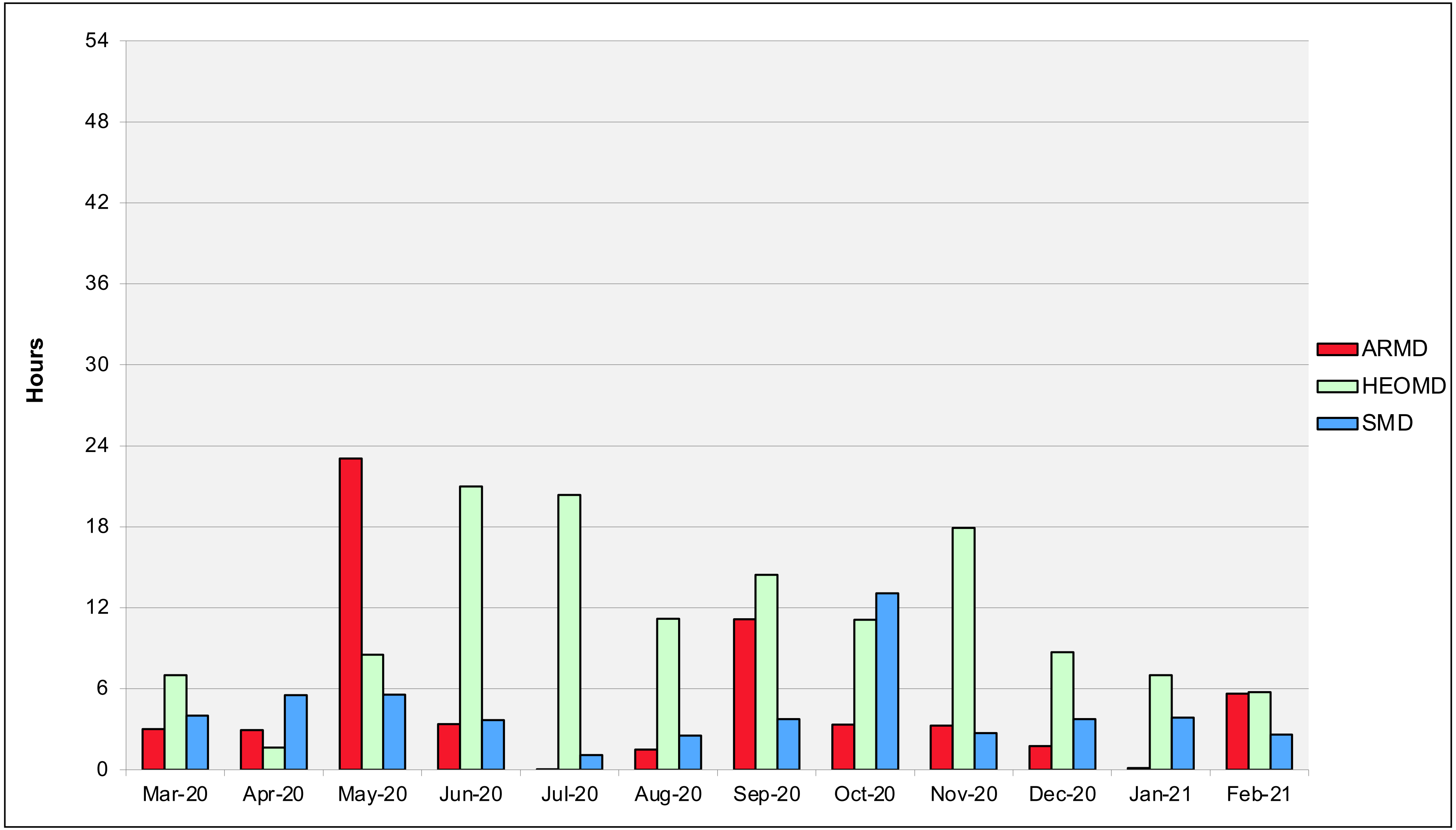
Merope: Monthly Utilization by Job Size



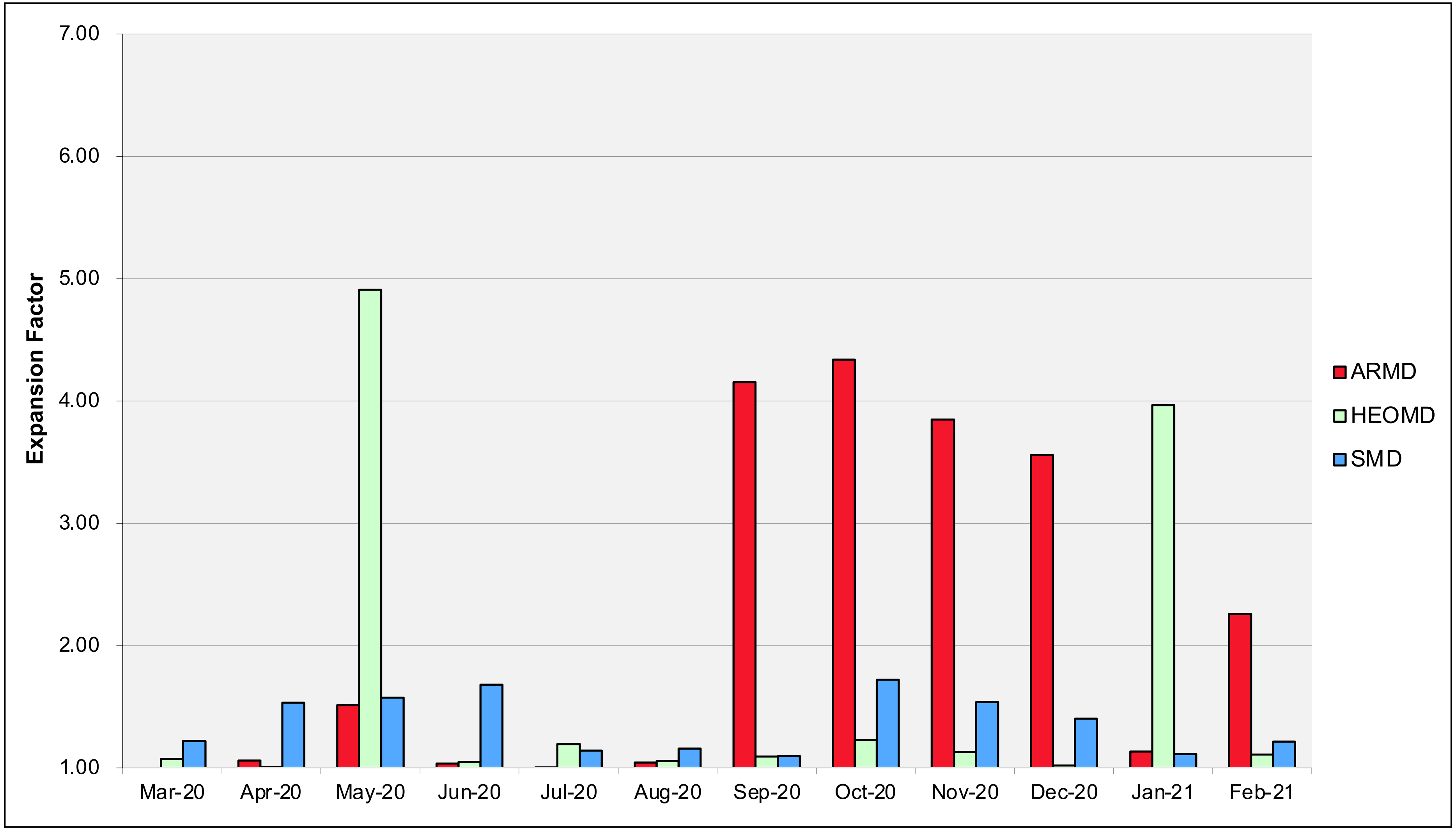
Merope: Monthly Utilization by Size and Length



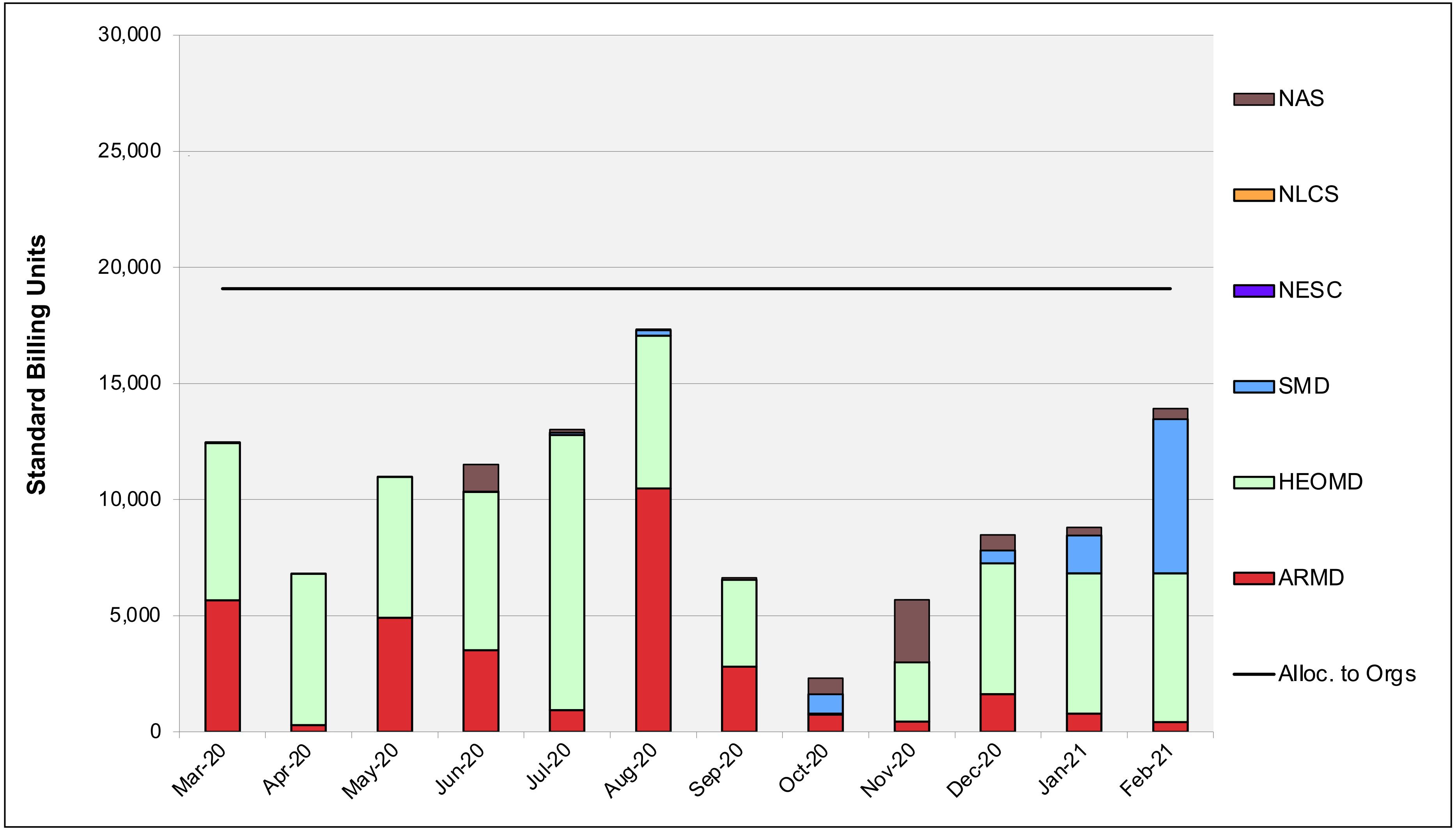
Merope: Average Time to Clear All Jobs



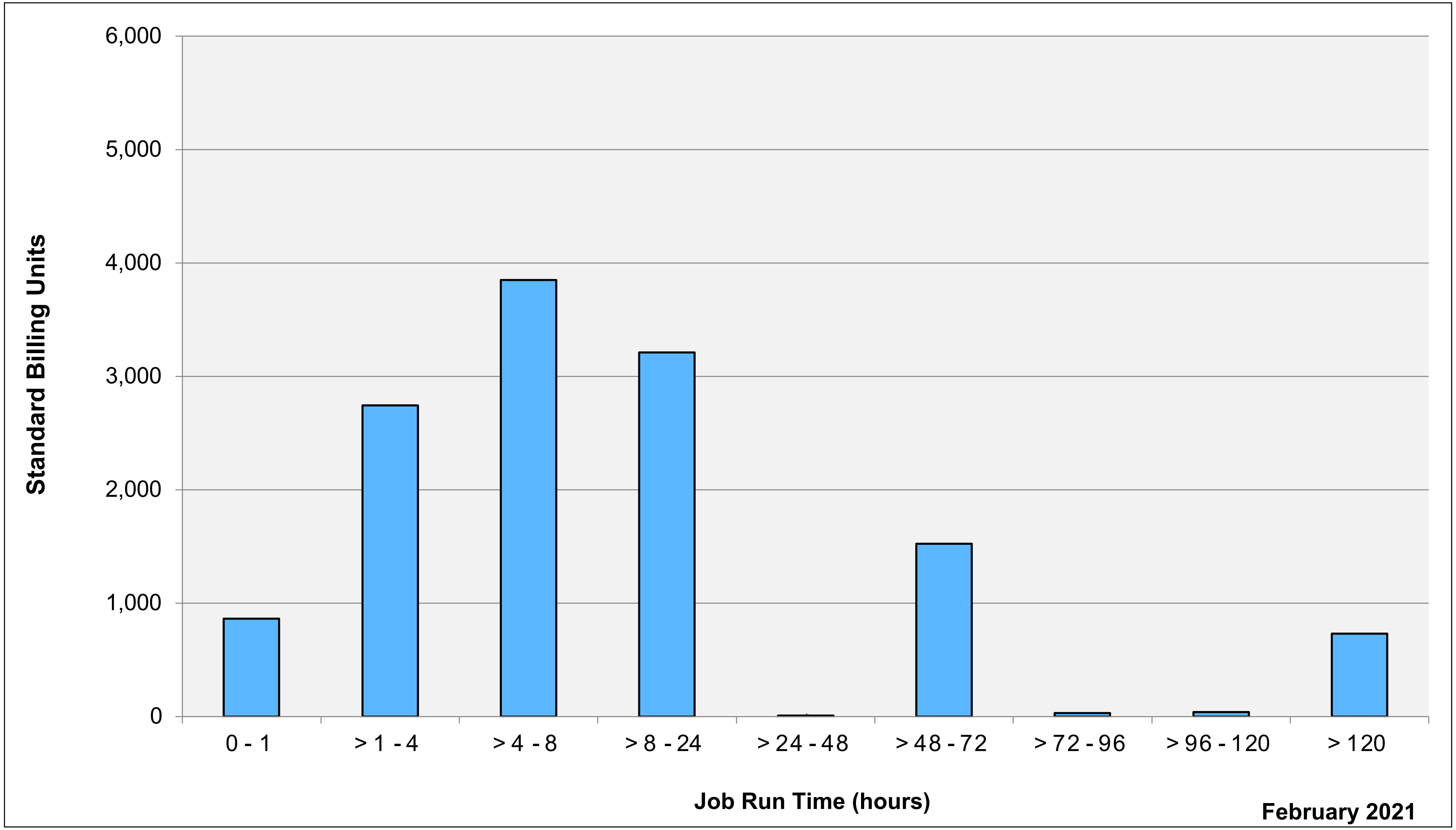
Merope: Average Expansion Factor



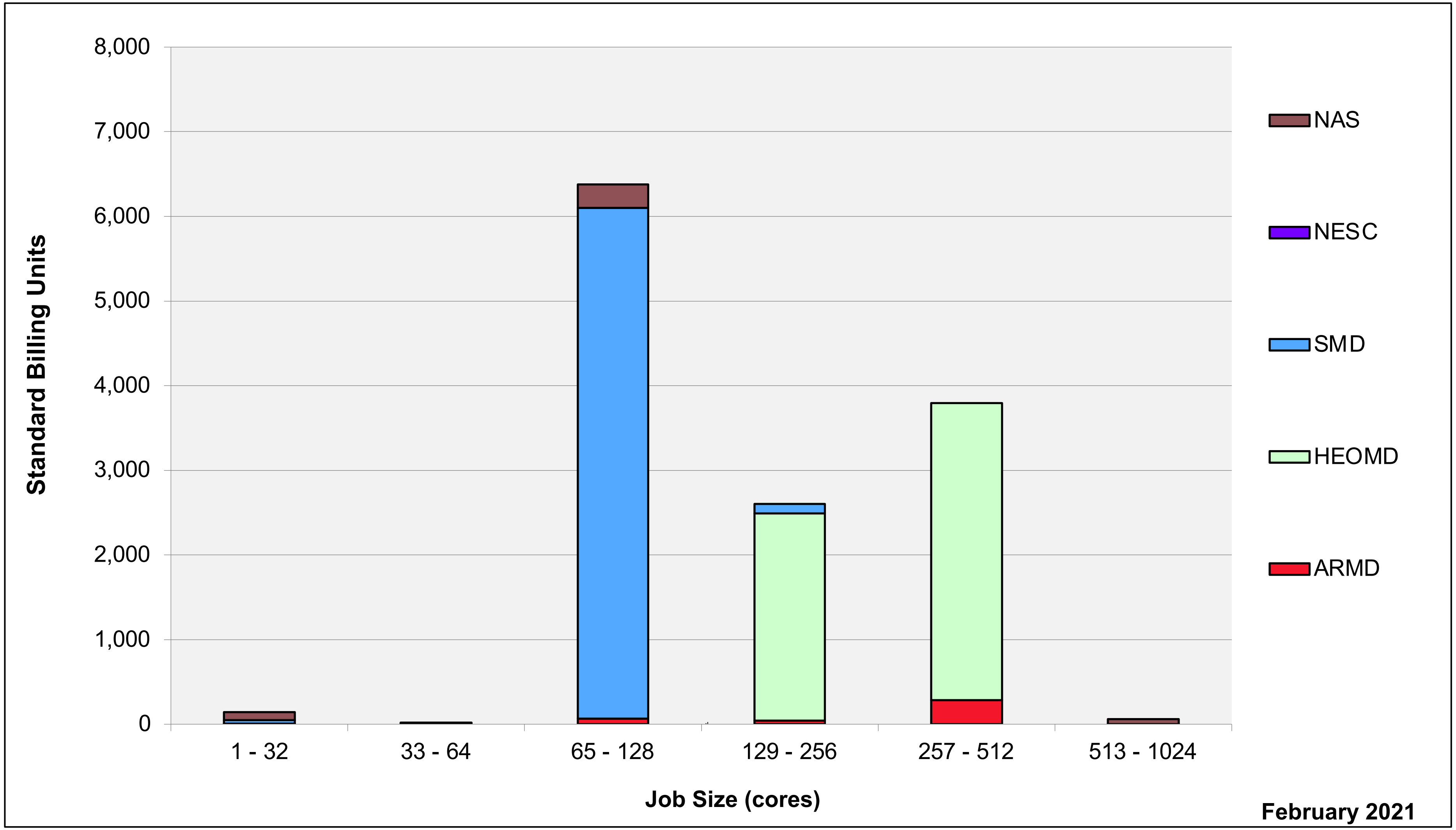
Endeavour: SBUs Reported, Normalized to 30-Day Month



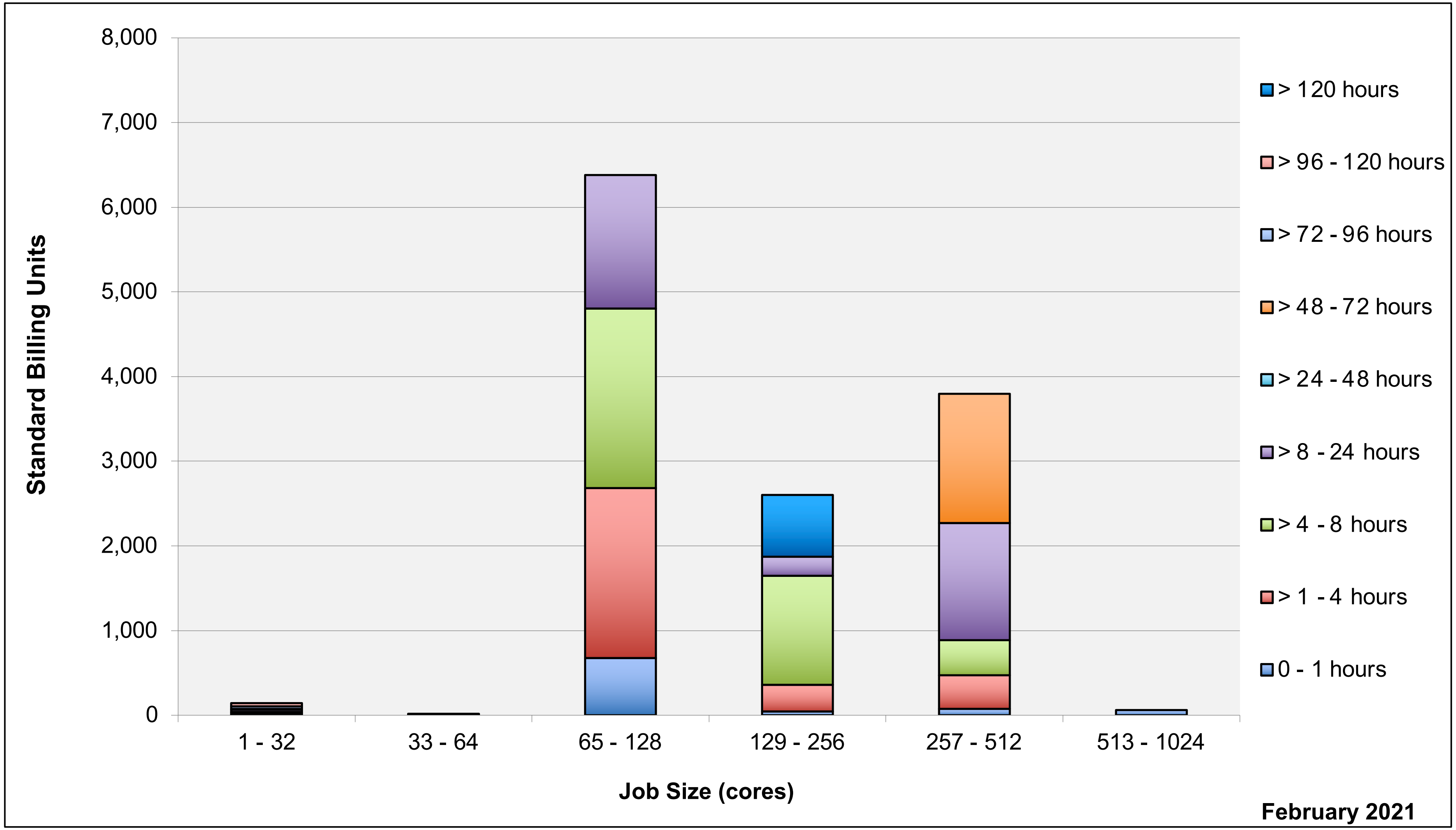
Endeavour: Monthly Utilization by Job Length



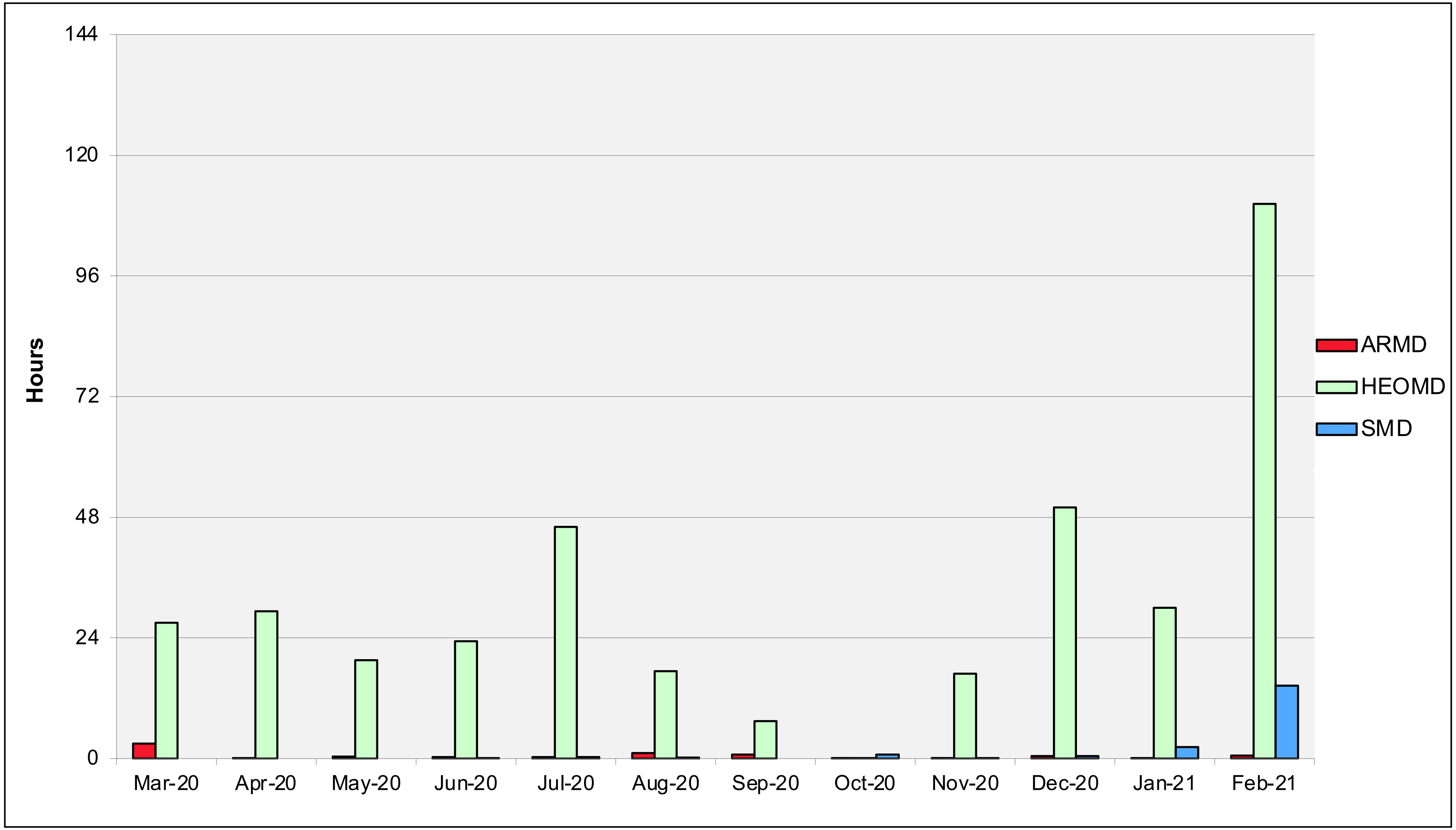
Endeavour: Monthly Utilization by Job Size



Endeavour: Monthly Utilization by Size and Length



Endeavour: Average Time to Clear All Jobs



Endeavour: Average Expansion Factor